Ontario Hydro

RESEARCH DIVISION

91600
new 82-10

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

ontario hydro
research division

ANALYSIS OF THE METEOROLOGY ASSOCIATED WITH FIVE 1981 PRECIPITATION CHEMISTRY EPISODES

Report No 85-39-K

Y.T. Tam
Atmospheric Physicist
Atmospheric Research Section
Chemical Research Department

ABSTRACT

Air and precipitation quality data have been collected in Ontario by Ontario Hydro, the Atmospheric Environment Service of Canada and the Ontario Ministry of the Environment. Five precipitation episodes in 1981 were studied to explore the relationship between the mesoscale weather features and the precipitation chemistry. Results demonstrated that precipitation contaminated with pollutants such as $SO_4^=$ and NO_3^- can occur in Ontario when a cyclone with warm front development is located over the upper Great Lakes area. Precipitation can also occur when an anticyclone is located over the New England and/or Maritime Provinces area. Both conditions produce southerly winds in Ontario. Concentrations of $SO_4^=$ and NO_3^- are larger in the summer than in the winter, although the seasonal variation of $SO_4^=$ is larger than that of NO_3^-.

job	file	date	report no.
740635-537-091	837.08	February 26, 1985	85-39-K

ontario hydro
research division

EXECUTIVE SUMMARY

A dense network of air and precipitation sampling stations has been established in Ontario by the Atmospheric Research Section of Ontario Hydro's Research Division, the Atmospheric Environment Service of Canada and the Ontario Ministry of the Environment. Five 1981 precipitation episodes were selected for detailed study.

For each episode, the surface synoptic weather patterns were analyzed first to determine the meteorological conditions and the amount, duration and type of the precipitation. The precipitation chemistry data ($SO_4^=$ and NO_3^- concentrations) were then examined to determine their relationship to the meteorological data.

Results of the analysis indicated that synoptic weather conditions associated with the precipitation episodes were cyclones with frontal development moving into the study area from the south and southwest; anticyclones with or without frontal development located to the northeast of the study area; and squall lines, including pre-frontal troughs. Among these synoptic conditions, cyclones with warm fronts dominated the precipitation patterns.

Concentrations of $SO_4^=$ and NO_3^- depended strongly on the amounts and rates of precipitation. The concentrations of these species were greatest in the summer and least in the winter. Again, warm frontal precipitation contributed the highest $SO_4^=$ and NO_3^- concentrations in the sampling area.

When examined by wind direction, most precipitation occurred with southerly winds and a fraction with easterly winds. The $SO_4^=$ and NO_3^- concentrations followed the wind direction pattern very closely. Thus, the prevailing wind direction may be used as a predictor of the largest gradient of precipitation quality.

job	file	date	report no.
740635-537-091	837.08	February 26, 1985	85-39-K

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
	1.1 Background	1
	1.2 Scope of the Present Study	2
2.0	EXPERIMENTAL	2
3.0	METEOROLOGY	5
	3.1 Episode 1: February 1 to 3, 1981	5
	3.2 Episode 2: February 10 to 12, 1981	8
	3.3 Episode 3: February 22 to 24, 1981	11
	3.4 Episode 4: May 9 to 12, 1981	14
	3.5 Episode 5: August 29 to 31, 1981	17
4.0	PRECIPITATION CHEMISTRY	19
	4.1 Episode 1: February 1 to 3, 1981	19
	4.2 Episode 2: February 10 to 12, 1981	24
	4.3 Episode 3: February 22 to 24, 1981	24
	4.4 Episode 4: May 9 to 12, 1981	29
	4.5 Episode 5: August 29 to 31, 1981	33
5.0	DISCUSSION OF RESULTS	37
6.0	CONCLUDING REMARKS	39
	REFERENCES	41
	APPENDIX	42
	DISTRIBUTION	last page

91601
new 82-10

ontario hydro
research division

To Mr. F.J. Kee
Director of Research

ANALYSIS OF THE METEOROLOGY ASSOCIATED WITH FIVE 1981 PRECIPITATION CHEMISTRY EPISODES

1.0 INTRODUCTION

1.1 Background

Ontario Hydro (OH), the Atmospheric Environment Service of Canada (AES) and the Ontario Ministry of the Environment (OME) established sampling networks to measure air and precipitation quality in Ontario and, in the case of AES, elsewhere in Canada in the late 1970's to early 1980's. The networks provide a reasonably continuous record of air and precipitation chemistry data in areas of central Ontario, known to be sensitive to the effects of acidic deposition.

Earlier Ontario Hydro studies in this area focussed on the quality control (Handy, 1981) and the statistical properties of the data (Jarv, 1983). Results of those studies showed that sampling sites with higher ion concentrations were in close proximity to each other and closer to major urban and suburban areas. Concentrations of $SO_4^=$ and NO_3^- in precipitation were the most significant predictors of pH and acid concentration, H^+. Further, neither multiple linear regression analysis nor factor analysis were appropriate for use with the entire data set. This deficiency may be attributed to the fact that meteorological parameters were not taken into consideration in these statistical analyses.

Using 850 mb weather data and modified surface geostrophic winds to analyze precipitation chemistry data collected at Dorset, Ontario, during the period from August 28 to September 4, 1981, Kurtz et al (1984) presented some positive relationships between the precipitation chemistry and the sector of trajectory origin. Again, no conclusion was drawn regarding the relationship between wet deposition and weather conditions.

Weather conditions are expected to have a direct influence on the amount and distribution of precipitation events which concurrently affect the wet deposition of air pollutants. Thus, the present study investigates the role of synoptic weather patterns on precipitation quality so that an acid precipitation climatology can begin to be identified.

1.2 Scope of the Present Study

Following a definition given by Thorp and Scott (1982), that a precipitation episode is a period of unsettled weather punctuated with precipitation events separated by more than six hours (three hours) of dry period in winter (summer), there were 105 precipitation episodes during the 1981 sampling period. Among these 105 episodes, five were chosen to explore in some detail the mesoscale features of the precipitation events and the associated precipitation quality.

The five episodes are February 1 to 3; February 10 to 12; February 22 to 24; May 9 to 12 and August 29 to 31, 1981. These five episodes are more or less typical of winter, spring and summer. For each episode, the surface weather maps were analyzed first to determine the synoptic scale meteorological conditions and the amount, duration and type of the precipitation. Supporting weather information was obtained from additional microscale meteorological variables such as wind speed and direction, temperature and cloud types. The precipitation chemistry data were then examined to investigate the relationship between meteorology and chemistry.

2.0 EXPERIMENTAL

Figure 1 displays the sampling sites of the combined OH, AES, OME network. There were 28 sites scattered throughout Ontario. Most of these sites were located in southern and central Ontario, along a line between Windsor and Chalk River. The coordinates and the closest Class A weather stations of these sampling sites are given in Table I.

Slightly different sampling instrumentation was used by OH, AES and OME. Generally, a wet-only Sangamo precipitation collector and a modified Sierra dichotomous air sampler were used in each OH site. These instruments were designed to be easily operated and serviced. Details have been discussed previously by Jarv (1982a) and will not be repeated here. AES also used the Sangamo sampler for precipitation collection, whereas OME utilized the Aerochemetrics sampler in their network. Both AES and OME used a downward-facing, open-face filter cassette, held ~10 m off the ground for air sampling.

The samples were collected over a 24-hour period starting at about 0800 EST and ending at 0800 EST the next morning. The precipitation samples were analyzed in the laboratory for the volume of the sample and the following parameters: pH, $SO_4^=$, NO_3^- Cl^-, H^+, NH_4^+, Ca^{++}, Mg^{++}, Na^+, K^+ and the ion balance. The filter cassette samples were analyzed for $SO_4^=$, $NO3^-$ and NH_4^+ aerosol, volatile nitrate (reported as NHO_3) and SO_2. These data were reported separately by OH, AES and OME. Respective examples are Jarv (1982b), Barrie et al (1981) an Chan (1983).

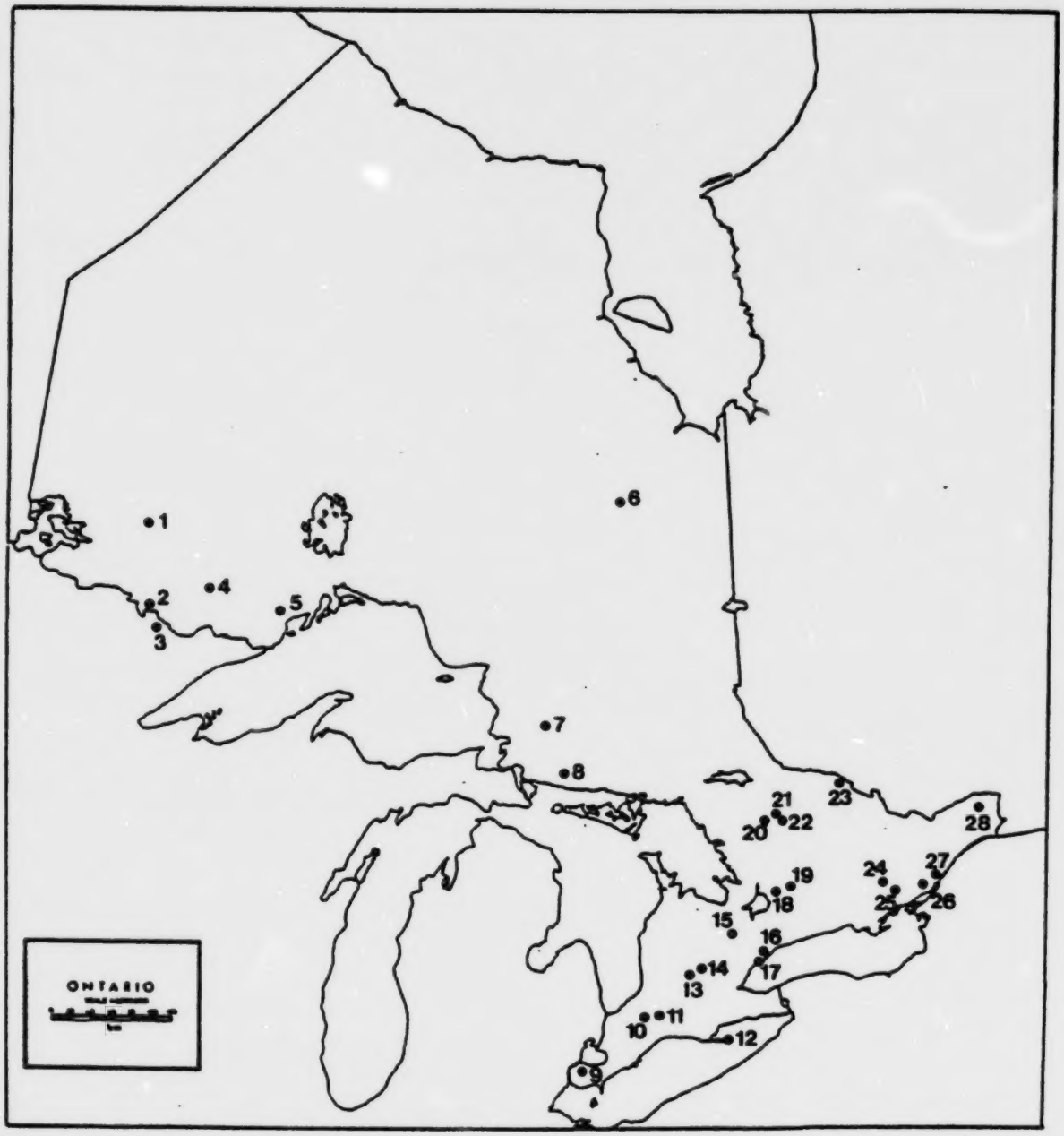


FIGURE 1

LOCATIONS OF THE PRECIPITATION QUALITY SAMPLING SITES

TABLE I

THE COORDINATES AND THE CLOSEST CLASS A
WEATHER STATION OF THE PRECIPITATION QUALITY SAMPLING SITES

	Site Name	Elev (m)	Latitude (N)	Longitude (W)	Closest Class A Weather Station
1	ELA	370	49°42'	93°54'	Sioux Lookout
2	Lac La Croix	368	48°21'	92°12'	Atikokan
3	Fernberg	506	47°50'	91°52'	Atikokan
4	Quetico Center	420	48°45'	91°12'	Thunder Bay
5	Forbes Township	324	48°38'	89°37'	Thunder Bay
6	Kapuskasing	308	49°24'	79°20'	Kapuskasing
7	Algoma	400	47°06'	84°06'	Sault Ste Marie
8	Mississagi	229	45°25'	83°22'	Sault Ste Marie
9	Essex	195	42°01'	82°53'	Windsor
10	Melbourne	213	42°47'	81°33'	London
11	Longwoods	239	42°53'	81°29'	London
12	Long Point	175	42°36'	80°30'	London
13	North Easthope	375	43°24'	80°53'	London
14	Wellesley	344	43°28'	80°46'	London
15	Orangeville	419	43°58'	80°02'	Toronto
16	Toronto - 427	115	43°37'	79°33'	Toronto
17	Toronto - CN Tower	423	43°42'	79°24'	Toronto
18	Raven Lake	274	44°37'	78°54'	Toronto
19	Balsam Lake	259	44°38'	78°51'	Toronto
20	Nithgrove	325	45°12'	79°04'	North Bay
21	Dorset - OME	320	45°13'	78°56'	North Bay
22	Dorset - OH	320	45°13'	78°56'	North Bay
23	Chalk River	122	46°06'	77°04'	Petawawa
24	Whitman Creek	137	44°29'	76°49'	Trenton
25	Railton	137	44°29'	76°49'	Trenton
26	Charleston Lake	92	44°30'	76°03'	Trenton
27	Graham Lake	130	44°35'	75°52'	Trenton
28	Vankleek Hill	114	45°31'	74°39'	Ottawa

The required meteorological data were obtained from routine synoptic weather maps and observations at those Class A weather stations available at AES. The meteorological data used for the present episodic studies are stored in a computer data base and could be displayed graphically using a computer program developed by Pressnail (1983).

3.0 METEOROLOGY

This section describes the meteorological conditions of the five precipitation episodes being studied. For convenience, most of the detailed meteorological data are concentrated in the appendices.

3.1 Episode 1: February 1 to 3, 1981

Prior to this episode, on January 31, the dominant synoptic scale weather features in North America were two high pressure systems. The southern high was centered over Pennsylvania and the northern one was over the Canadian Northwest Territories. There was a deep trough between these two highs. On the following day, the centre of the southern high moved gradually eastward to the Atlantic coast while the northern high moved southward to the Canadian Prairie Provinces. This movement resulted in warm and moist air from the south meeting cold and dry air from the north and eventually a frontal disturbance developed along the trough.

Further south to the United States, there was another low pressure system located in Kansas and moving toward the Great Lakes area on February 1. This low pressure system and the above-mentioned trough established a large precipitation band covering the entire area of Ontario and the central portion of the United States.

By 0700 EST, February 1, the centre of the Kansas low had moved over Wisconsin and North Michigan with a warm front extending to Indiana. By the same time, the centre of the Pennsylvania high had moved off the New York-New Jersey coast. This high blocked the movement of the low and caused the fronts to be oriented in a north-south direction. Continuous snow was observed over the central and southern Ontario area. In fact, precipitation was first observed in London at 0800 EST and four hours later in Trenton.

Hobbs (1978) has classified precipitation bands into five types according to their location in the extratropical cyclones. They are known as warm frontal precipitation, warm sector precipitation, cold frontal precipitation, surge precipitation and post frontal precipitation. Based on this classification, the precipitation observed in southern Ontario at this time could be classified as warm frontal.

Six hours later at 1300 EST, the New York-New Jersey high had begun to weaken and the Wisconsin low had moved to the north shore of Lake Superior. Another frontal disturbance was developing over southern Michigan. Warm fronts associated with these lows were oriented in an east-west direction, due to the strong southwesterly flows generated by the highs. Precipitation in southern Ontario during this period was also classified as warm frontal.

An interesting synoptic scale feature at this time was that the precipitation band became an isolated cell (see weather maps in Appendix A). This was due to the strengthening of a high pressure system over the Prairie Provinces, which controlled the synoptic weather of the whole area west of the Great Lakes.

On February 2, the Michigan low moved further to the east to lie over the Georgian Bay area. A cold front extended southwesterly through Lake Huron to the Great Plains States. Though precipitation was recorded at all sampling sites, precipitation types varied significantly. In southern Ontario, sampling sites 9 to 15 collected precipitation of the cold frontal type. Sites 16, 17 and 24 to 27 collected warm sector precipitation and sites 18 to 23 warm frontal precipitation.

As the day progressed, the centre of the low continued to intensify and move eastward. Two cold fronts were observed from the weather map at 0700 EST, February 2. One cold front extended southward through Lake Ontario to the Appalachian States. Another one was southwestward through Georgian Bay, Lake Huron to the US Midwest. A warm front was eastward toward the Maritime Provinces. The precipitation area became smaller than on the previous day. The precipitation observed at southern Ontario was of the cold frontal type during this hour.

The low pressure system moved out of Ontario at 1300 EST, February 2. However, a weak cold front was still in southern Ontario producing small amounts of precipitation in that area. The entire low pressure system moved to eastern Quebec and weakened considerably at 1900 EST, February 2. Only occasional snow showers were observed in Ontario. This precipitation episode ended at 0100 EST, February 3.

The tracks of the surface low pressure centres for this precipitation episode are shown in Figure 2. Note that the tracks were generally smooth. The lows moved from southwest to northeast at an almost uniform speed.

Table II illustrates the amount, duration and rate of precipitation at six Class A weather stations in southern and central Ontario during this episode. It can be seen that the precipitation amount and duration decreased from the southern stations to the northern stations with the exception of North Bay. The surface weather observations at these stations, as given in Appendix A, indicate that most of the precipitation was associated with stratiform clouds.

FIGURE 2

TRACKS OF SURFACE LOW PRESSURE CENTRES FOR
PRECIPITATION EPISODE 1, FEBRUARY 1-3, 1981
EACH INTERVAL REPRESENTS 6 HOURS

TABLE II

PRECIPITATION STATISTICS AT SIX WEATHER STATIONS
FOR PRECIPITATION EPISODE 1, FEBRUARY 1-3, 1981

Weather Station	Precipitation Amount (mm)	Precipitation Duration (hour)	Precipitation Rate (mm/h)
London	22.9	44	0.52
Toronto	9.5	23	0.41
Trenton	9.9	26	0.38
Ottawa	10.8	27	0.40
Petawawa	5.0	28	0.18
North Bay	14.6	39	0.37

In summary, precipitation during this episode was mainly caused by frontal disturbances. Warm air approaching from the south was lifted over cold air. Because of the uplift, the warm air cooled adiabatically and produced stratiform clouds. Precipitation was heavy at the beginning of the lifting, but decreased rapidly thereafter. As shown in Table II, precipitation in London was more than twice that in Ottawa.

3.2 Episode 2: February 10 to 12, 1981

On February 9, the weather in eastern North America was dominated by a low pressure system centered over Labrador and a high pressure system located on the coastline of South Carolina. A cold front extended from the Labrador low southwestward through the lower Great Lakes to the US Midwest.

There was another low pressure system developing in the Texas Panhandle area. This low pressure system, in combining with the above-mentioned cold front, generated a precipitation area covering the southern Great Plains.

At 0100 EST, February 10, the Labrador low began to weaken and moved off the coast. The Texas low, on the other hand, intensified quite rapidly to become an extratropical cyclone and moved toward the Great Lakes. Six hours later, at 0700 EST, the centre of the cyclone had moved to the border of Missouri and Arkansas. Relatively heavy precipitation was observed over much of the central portion of the US.

This cyclone continued to deepen and was centered over central Illinois by 1300 EST, February 10. Also by this time, a rapidly strengthening high pressure system had moved from the north Pacific coast to the Dakotas. This high pressure system enhanced the northward movement of the cyclone to the Great Lakes area. Snow began falling at Thunder Bay at 0900 EST and by 1300 EST, almost the entire Province of Ontario was under the influence of the precipitation area of this cyclone. The precipitation was in the form of snow except for Windsor where rain was reported. This precipitation was classified as warm frontal.

By 1900 EST, the cyclone had moved to the east shore of Lake Michigan. There was a secondary low centre developing over Indiana. Multiple fronts were associated with these two lows.

During this time, the weather in the area west of the cyclone was dominated by a quasi-stationary high pressure system whose centre was over the central part of the US. An extremely cold arctic air mass was driven to the US Midwest by this high pressure system. Record low temperatures included -36°C at International Falls, Minnesota and -31°C at Duluth, Minnesota. Due to this high pressure system, the cyclone was forced to move northward and eastward. The precipitation area then covered the entire Great Lakes and the New England region.

On February 11, the centres of the cyclone were located over central Ontario on the north shore of Lake Huron and Ohio south of Lake Erie. The associated warm fronts extended to the east and the cold fronts to the south. This led to a "comma" pattern of cyclonic disturbance as seen from the weather maps given in Appendix B.

The "comma" pattern disturbance is generally very vigorous because it is associated with a surface pressure trough and heat, moisture and momentum fluctuations. In fact, thunderstorms and showers were observed along the "comma" tail region on this day. The precipitation in southern Ontario during the morning hours on February 11 was classified as warm frontal. However, in the afternoon when the centre of the cyclone had moved to Quebec, the precipitation was of the cold frontal type. The major precipitation area had moved to eastern Quebec by 1900 EST, February 11. Precipitation was observed occasionally in the southern and most eastern part of Ontario near the Quebec border. This precipitation episode ended at 0100 EST, February 12.

Figure 3 displays the tracks of the centres of the cyclone for this precipitation episode. The amount, duration and rates of precipitation at five Class A weather stations in southern and central Ontario during this episode are presented in Table III. It can be noted that precipitation rates during this episode were larger than those in the previous one. The south to north decreasing tendency is also seen in the table. Again, most of the precipitation was associated with stratiform clouds (see Appendix B).

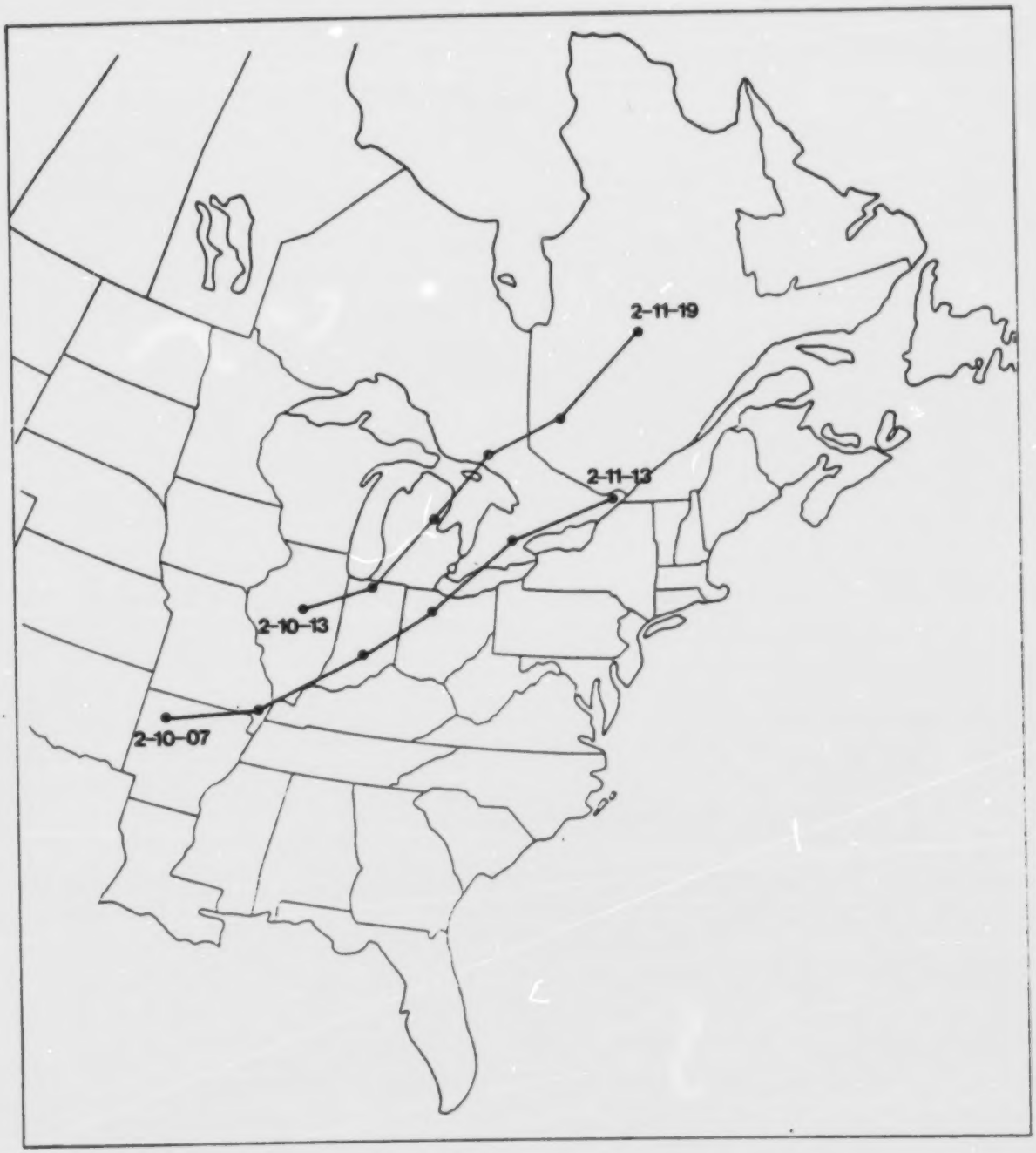


FIGURE 3

TRACKS OF SURFACE LOW PRESSURE CENTRES FOR PRECIPITATION EPISODE 2, FEBRUARY 10-12, 1981

In summary, precipitation during this episode was associated with a rapidly intensifying cyclone storm which moved from the Texas Panhandle to the Great Lakes in advance of a cold outbreak. Precipitation was widespread from the southern Great Plains through the Great Lakes to New England. Heaviest amounts occurred in southern Ontario. Thunderstorms and showers were also observed during this episode.

TABLE III

PRECIPITATION STATISTICS AT FIVE WEATHER STATIONS FOR PRECIPITATION EPISODE 2, FEBRUARY 10-12, 1981

Weather Station	Precipitation Amount (mm)	Precipitation Duration (hour)	Precipitation Rate (mm/h)
Windsor	38.8	40	0.97
London	39.5	46	0.86
Toronto	28.7	26	1.10
Trenton	27.4	27	1.01
Ottawa	28.8	34	0.85

3.3 Episode 3: February 22 to 24, 1981

The synoptic weather features over the eastern portion of North America on February 22 were dominated by two low pressure systems: one located over the US Midwest and another over Quebec.

The US low moved gradually toward the Great Lakes. At 1300 EST, February 22, it was located over North Michigan with a warm front extended across Lake Superior to central Ontario. Warm frontal precipitation was observed at sampling sites 5,7 and 8.

At the same time, a high pressure system was developing over the Nova Scotia area. Another high pressure system was located over the Rocky Mountains. These two highs began to take on blocking characteristics on February 23. Between the low and the Nova Scotia high, a squall line developed from Lake Ontario to the US Appalachian States at 0700 EST (see Appendix C). Significant precipitation was concentrated along this line and the warm front area over northern Ontario. Accordingly, the precipitation observed at sampling sites 1 to 6 and 23 and 28 was of the warm frontal type. That observed at sampling sites 9 to 21 and 24 to 27 was of the warm sector type.

By 1300 EST, the precipitation area became smaller and moved eastward and northward. Strong southwesterly flow was observed over the southeastern portion of the United States. Sampling sites 1 to 5 were still in the warm frontal precipitation region and sampling sites 9 to 28 were in the warm sector precipitation region.

On February 24, the low pressure system began to weaken. However, the influx of southerly flow was still apparent in the Great Lakes area. Precipitation in the form of rain was observed at sampling sites 6 to 8 and 18 to 25. The amount of precipitation was much less on this day than on the previous ones. Foggy weather was observed in southern Ontario at 0700 EST. This episode ended at 1300 EST, February 24.

Figure 4 displays the tracks of the low pressure centres for this episode. The blocking of the eastward movement of the low centre is somewhat depicted in the figure.

Table IV shows the amount, duration and rates of precipitation at six Class A weather stations for this episode. As can be seen in the table, more precipitation was observed in southern Ontario than in northern Ontario. Ottawa reported three times more precipitation than Sioux Lookout. Stratiform clouds, too, were observed throughout the Province during this precipitation episode as shown in Appendix C.

TABLE IV

PRECIPITATION STATISTICS AT SIX WEATHER STATIONS
FOR PRECIPITATION EPISODE 3, FEBRUARY 22-24, 1981

Weather Station	Precipitation Amount (mm)	Precipitation Duration (hour)	Precipitation Rate (mm/h)
London	21.2	31	0.68
Trenton	27.8	23	1.21
Ottawa	29.0	42	0.69
Petawawa	15.0	28	0.54
Kapuskasing	15.9	29	0.55
Sioux Lookout	9.6	39	0.25

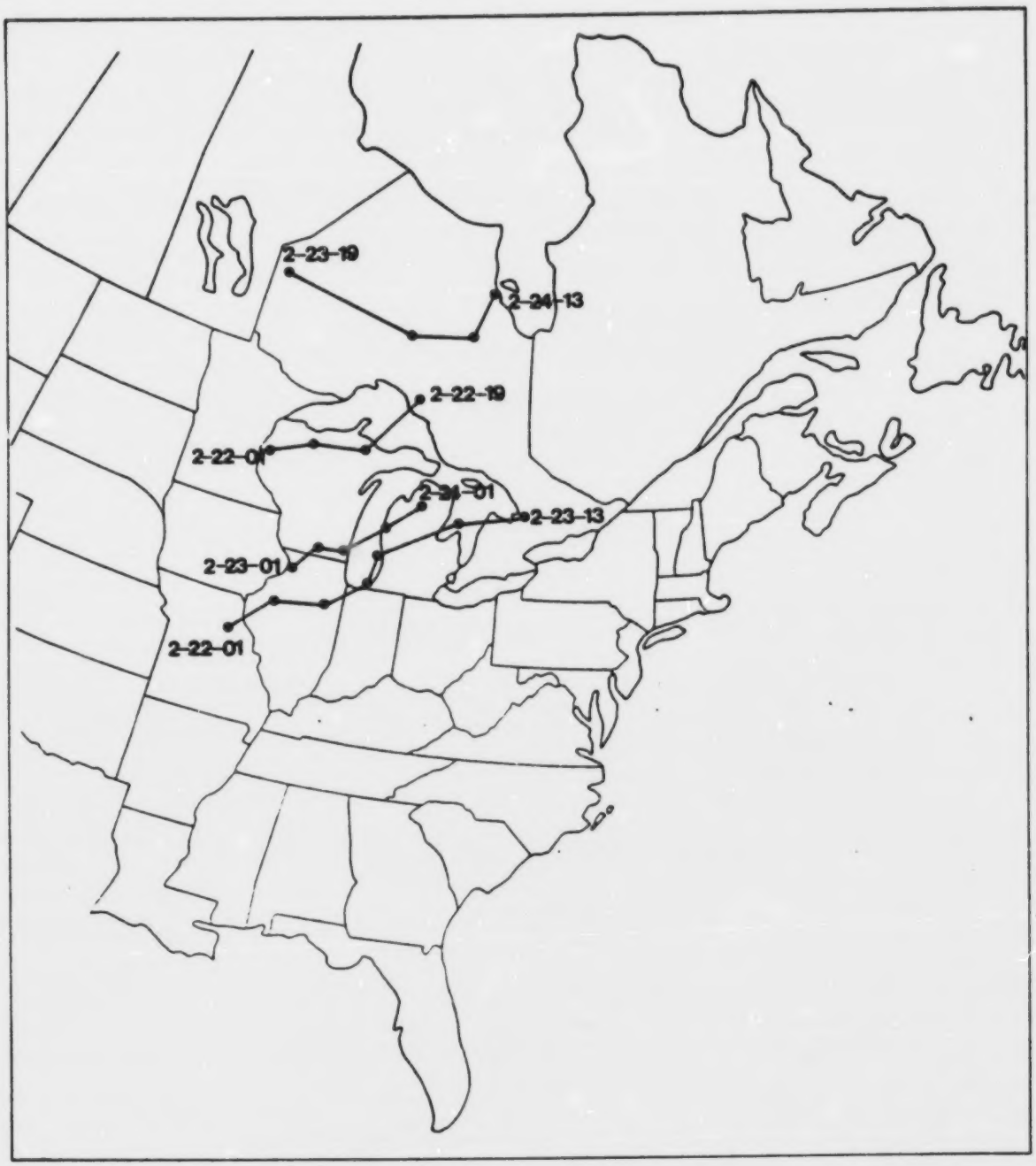


FIGURE 4

TRACKS OF SURFACE LOW PRESSURE CENTRES FOR
PRECIPITATION EPISODE 3, FEBRUARY 22-24, 1981

In summary, precipitation during this episode was mainly due to a quasi-stationary low pressure system and a squall line. The low pressure system was located over the upper Great Lakes area and the squall line extended from Lake Ontario to the US Appalachian States. Southerly air was driven northward into Ontario by these systems. However, because the air masses from the north were not very cold, the precipitation observed at the sampling sites was in the form of rain. Heavier amounts occurred in southern Ontario than in the northern part of the Province.

3.4 Episode 4: May 9 to 12, 1981

On May 8, the weather over the Great Lakes area was dominated by a high pressure system. However, this high pressure system moved quickly to the east and was replaced by a series of lows and associated frontal systems. At 0100 EST, May 9, a low centre was located over Minnesota with a warm front extended eastward through the north shore of Lake Superior to Quebec. Snow was observed at sampling sites 2 to 5. Another low was centered over Indiana with a trough stretched northward to Lake Michigan. Further south to the US, a subtropical low was developing in the Texas Panhandle area. This Texas low became an active cyclone at 0700 EST and moved northeastward toward the Great Lakes area. Thunderstorms were observed in the area around the centre of the cyclone. At the same time, the Indiana low moved to the west end of Lake Erie. A trough of warm air aloft was observed over the southern Ontario area from Windsor to North Bay. Showers and warm frontal precipitation were observed at sampling sites 9 to 11, 13 to 15 and 20 to 22. Snow was observed at sampling sites 1 to 4 due to the frontal disturbances to the north.

By 1300 EST, a strengthening high pressure system was located over Manitoba. This high, in conjunction with a ridge over eastern Canada and the US restricted the movement of the frontal system from southwest to northeast. Precipitation was observed at sampling sites 9 to 17.

On May 10, northern Ontario was under the influence of the Manitoba high which continued to strengthen and established a blocking ridge over northern Ontario and Quebec (see Appendix D). No precipitation was observed in that area. Further, a cold front associated with this high was observed from northern Quebec through Lake Huron to the US Midwest. Record low temperatures were measured in the north-central States. Precipitation due to this cold front was observed in most of the southern Ontario sampling sites throughout the day.

Also by May 10, the previously-mentioned Texas low had moved to Missouri and Illinois. Maritime warm air was driven northward to the lower Great Lakes area by this low. Warm frontal precipitation was observed at sampling sites 9 to 12 while sampling sites 13 to 18 were still in the cold frontal precipitation region at 0900 EST, May 10.

On May 11, the low was centered over Indiana with warm fronts across southern Ontario in the morning hours. Precipitation was widespread. Heaviest amount occurred in southern Ontario, Ohio Valley and New England. Precipitation in southern Ontario was of the warm frontal type.

At 1300 EST, the blocking high was centered over Labrador and significantly weakened. The low system had also moved eastward to Pennsylvania. Precipitation in southern Ontario was due to the cold fronts from the St. Lawrence River to the lower Great Lakes. The whole synoptic weather system continued to move eastward. At 0100 EST, May 12, the southern Ontario area was reported rainless but occasional rain was reported in central Ontario. The precipitation episode ended at 0700 EST, May 12.

The tracks of the surface low pressure centres and the precipitation statistics at eight selected Class A weather stations for this episode are given in Figure 5 and Table V. The surface weather observations at these stations are presented in Appendix D.

TABLE V

PRECIPITATION STATISTICS AT EIGHT WEATHER STATIONS FOR PRECIPITATION EPISODE 4: MAY 9-12, 1981

Weather Station	Precipitation Amount (mm)	Precipitation Duration (hour)	Precipitation Rate (mm/h)
Windsor	28.3	40	0.71
London	23.5	57	0.41
Toronto	28.1	34	0.83
Trenton	35.3	42	0.84
Ottawa	45.0	41	1.10
Petawawa	55.5	47	1.18
North Bay	31.8	54	0.59
Wiarton	39.6	58	0.68

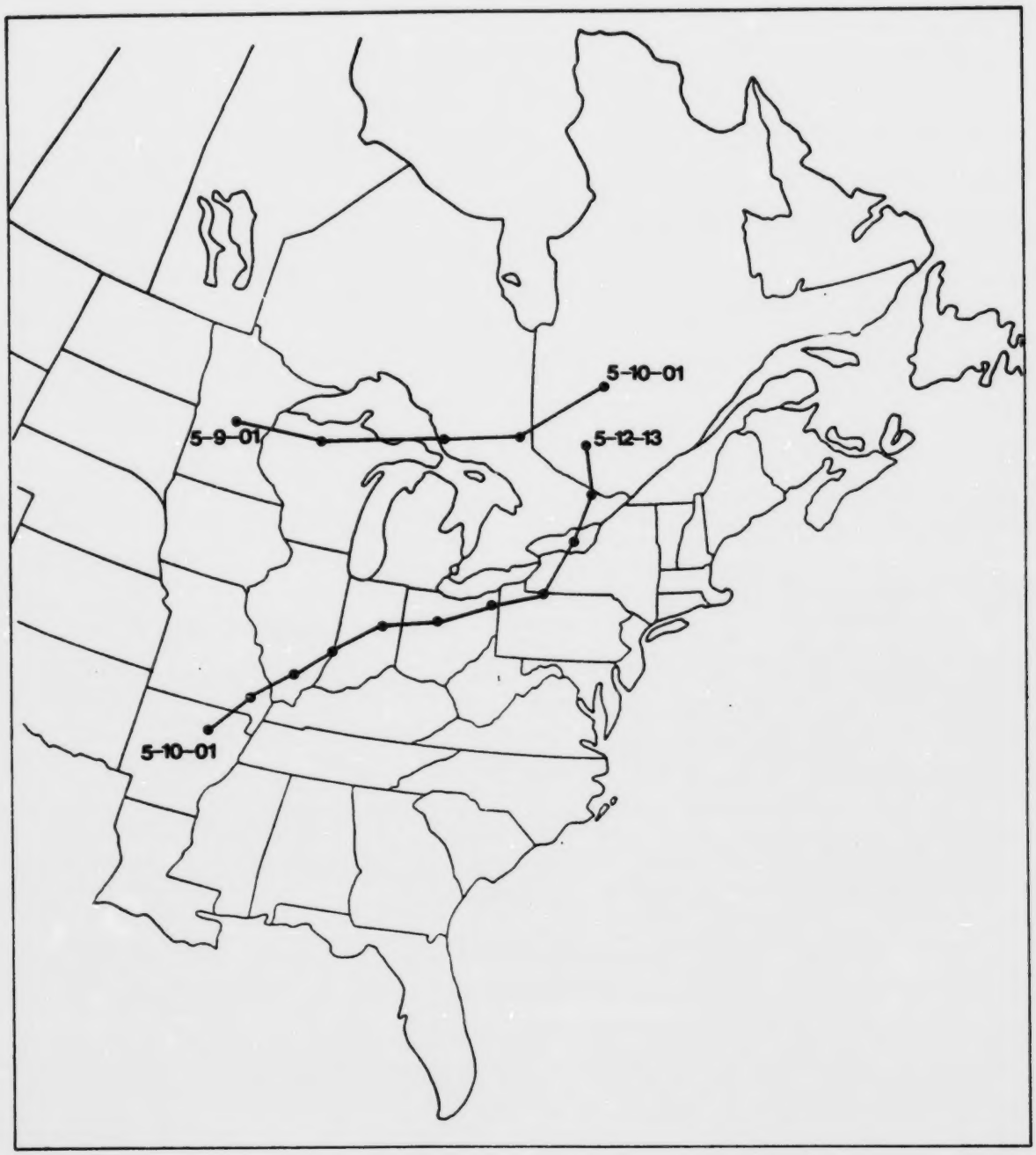


FIGURE 5

TRACKS OF SURFACE LOW PRESSURE CENTRES FOR PRECIPITATION EPISODE 4, MAY 9-12, 1981

In summary, the precipitation during this episode was mainly associated with a frontal system located in the transition region of two high pressure systems. Heavier precipitation was also associated with a cyclonic storm moving from the Texas Panhandle area to the Great Lakes. Because of the strong blocking high pressure system, the precipitation lasted much longer during this episode: the duration varied from 34 hours in Toronto to 58 hours in Wiarton.

3.5 Episode 5: August 29 to 31, 1981

On August 28, a strong blocking high pressure system was located over northern Ontario and Quebec and moved eastward and southward to the Maritimes and New England. South of this high pressure system was a frontal system whose associated precipitation area covered the entire area south of the Great Lakes.

On the following day, the high had moved to the New England States. The frontal had deepened with a warm front extending from Iowa across Georgian Bay to Lake Ontario. Warm frontal precipitation was observed at sampling sites 8 and 20 to 22.

At 0700 EST, August 29, a squall line was developing from the west end of Lake Erie southward to Tennessee. Thunderstorms were observed along this line. Southerly winds were observed in the eastern portion of the US. Precipitation observed in southern Ontario was of the warm sector type. This warm sector precipitation persisted to 1300 EST. During that period, the New England high pressure system became quasi-stationary. The squall line, on the other hand, weakened and became a trough, as can be seen in the weather maps given in Appendix E.

The fronts and trough dissipated on August 30. However, precipitation was still observed in the Great Lakes and southern Ontario areas. This precipitation was mainly due to the advection of warm and moist air from the south by a strong high pressure system whose centre was located just off the New England coast. The amount of precipitation during this time was relatively small, compared to that of the previous days.

The tracks of the low pressure centres are displayed in Figure 6. Table VI displays the amount, duration and rates of the precipitation at selected Class A weather stations for this episode. The corresponding surface weather observations at these stations are given in Appendix E.

In summary, precipitation during this episode was caused by frontal disturbances and high pressure systems. The centres of the low pressure systems were located over the US Midwest and nearly stationary. Heavier precipitation was reported in the Thunder Bay and Petawawa areas, consistent with the location of the warm fronts. After the frontal activity had weakened and diminished, the precipitation was due to the cooling of warm and moist air driven northward from the south by a high pressure system. Thunderstorms were also observed during this episode.

FIGURE 6

TRACKS OF SURFACE LOW PRESSURE CENTRES FOR PRECIPITATION EPISODE 5, AUGUST 29-31, 1981

TABLE IV

PRECIPITATION STATISTICS AT NINE WEATHER STATIONS
FOR PRECIPITATION EPISODE 5, AUGUST 29-31, 1981

Weather Station	Precipitation Amount (mm)	Precipitation Duration (hour)	Precipitation Rate (mm/h)
Windsor	55.0	12	4.58
London	28.8	12	2.40
Toronto	39.0	16	2.44
Trenton	12.1	14	0.86
Ottawa	12.8	9	1.42
Petawawa	57.6	14	4.11
North Bay	66.6	16	4.16
Wiarton	50.7	22	2.30
Thunder Bay	59.9	13	4.61

4.0 PRECIPITATION CHEMISTRY

This section describes the concentrations of $SO_4^=$ and NO_3^- in the precipitation collected during the five episodes being studied. These two chemical species were selected because of their importance in determining the acidity of precipitation.

The likely relationship between the distribution of these ionic concentrations and meteorology is also discussed for each episode.

4.1 Episode 1: February 1 to 3, 1981

Figure 7 displays the daily average $SO_4^=$ and NO_3^- concentrations in the precipitation collected at selected sampling sites in southern and central Ontario during this episode. It can be noted that, on a mass or equivalent basis, concentrations of NO_3^- were higher than those of $SO_4^=$ almost everywhere, throughout the episode.

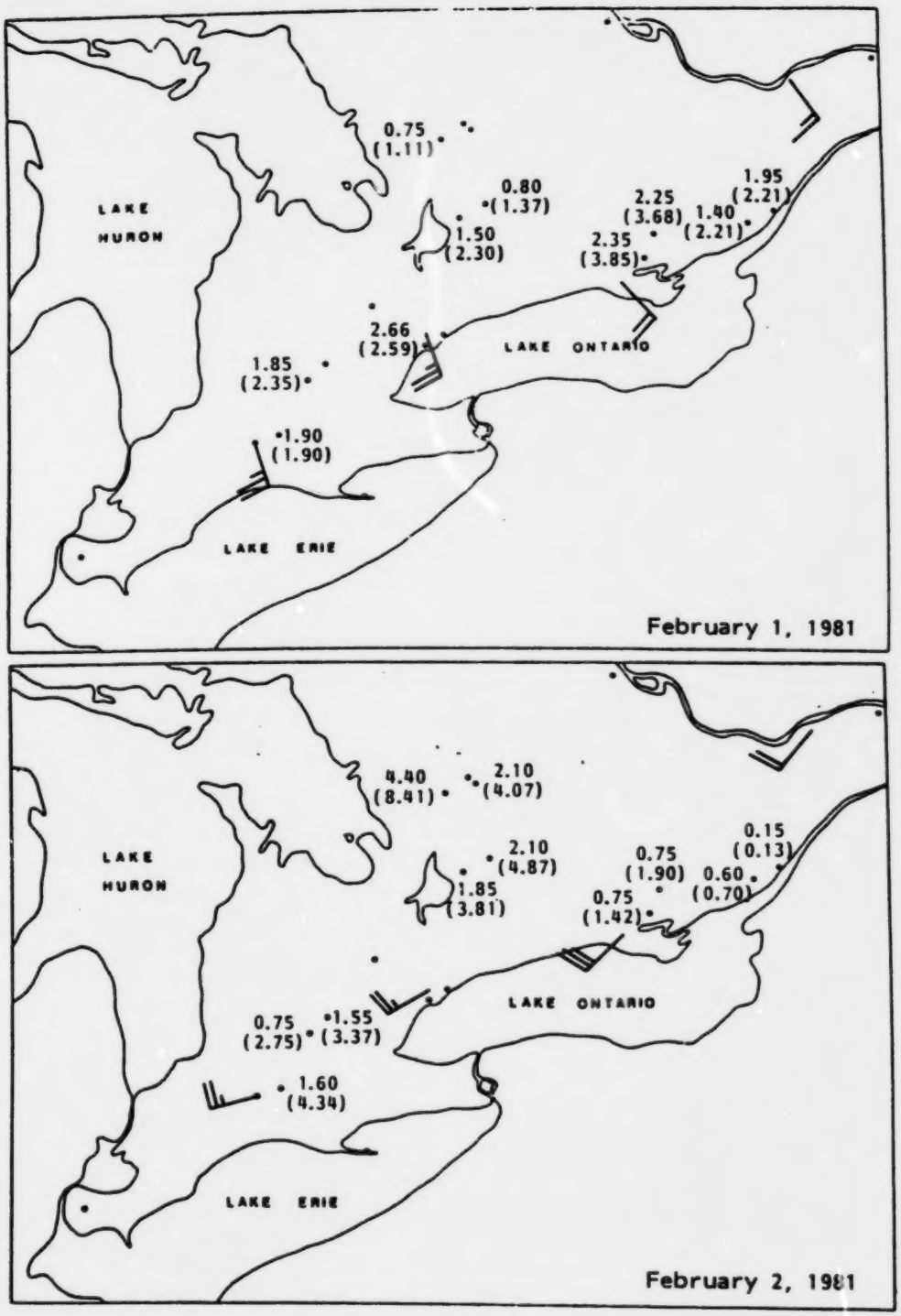


FIGURE 7

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 1, FEBRUARY 1 to 3, 1981

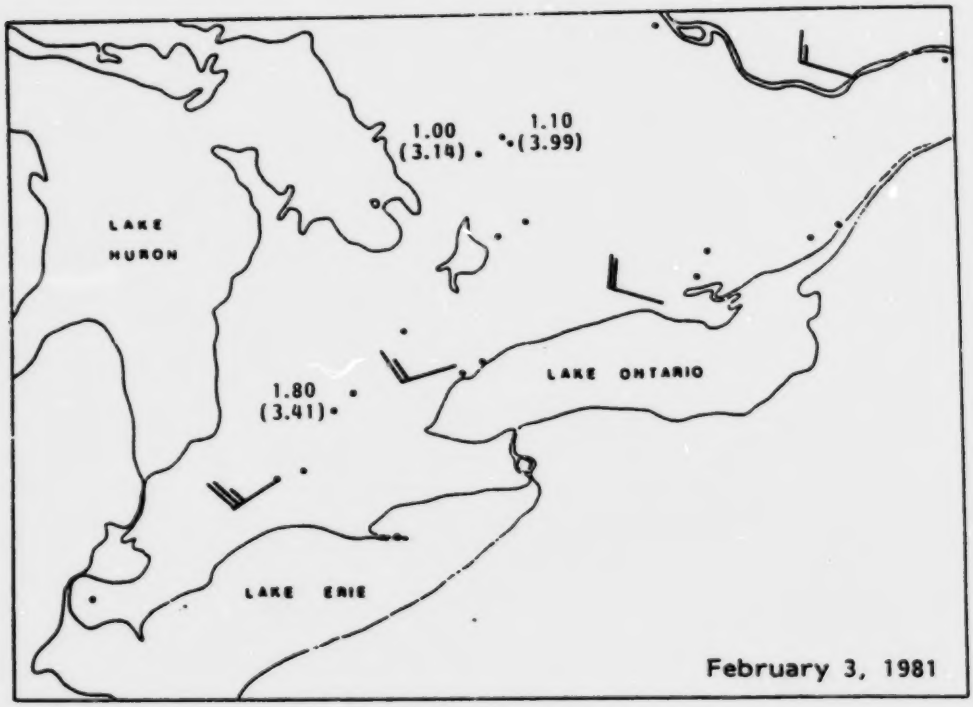


FIGURE 7
(cont'd)

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 1, FEBRUARY 1 to 3, 1981

More specifically, relatively high $SO_4^=$ and NO_3^- concentrations were measured in regions of southern Ontario and just north of Lake Ontario on February 1. The $SO_4^=$ concentrations decreased sharply in these regions on February 2. The NO_3^- concentrations, on the other hand, decreased only in the region north of Lake Ontario but increased elsewhere in southern Ontario.

It is also seen from Figure 7 that the $SO_4^=$ concentrations decreased in a direction from the southwest to the northeast, with the exception of the Lake Simcoe and Muskoka area, on February 2. Along this same direction, the NO_3^- concentrations increased on February 1 but decreased on February 2.

The $SO_4^=$ and NO_3^- concentrations measured in the Lake Simcoe and Muskoka region were very low on February 1, but increased quite rapidly, to values even higher than those measured in the southern Ontario region, on February 2. The maximum concentrations of $SO_4^=$ and NO_3^- were 4.40 and 8.41 mg/L, respectively. Both were measured at the Nithgrove Site. The concentrations of $SO_4^=$ and NO_3^- in this region decreased on February 3.

Figure 8 presents the average concentrations of $SO_4^=$ and NO_3^- for the entire precipitation episode. It should be noted that the averages for this episode were the arithmetic means because the daily amounts of precipitation at each site were not available. (For other episodes, with daily precipitation amounts, the average concentrations were weighted arithmetic means, with weighting factors equal to the amount of precipitation).

As shown in Figure 8, the maximum $SO_4^=$ concentration was measured in the Toronto area, while the maximum NO_3^- concentration was measured in the Muskoka area. Except at the Toronto site, the NO_3^- concentrations were higher than the $SO_4^=$ concentrations, both on a mass and equivalent basis.

As described previously, this episode was generated by frontal disturbances passing over Ontario. A warm front approached the study area from the south on February 1. This situation caused southerly flows over the southern Ontario area. The wind vectors at selected Class A weather stations are also shown in Figure 7. After the warm front had moved to the east, on February 2, the sampling area was under the influence of a series of cold fronts. Westerly winds predominated.

Combining the meteorology and the distributions of $SO_4^=$ and NO_3^-, it is seen that on February 1, when prevailing winds were southerly, the rate of decrease of $SO_4^=$ and NO_3^- concentrations was larger in the south to north direction than in the west to east direction. However, on February 2, when the winds were westerly, the rate of decrease was larger in the west to east direction than in the south to north direction. This suggests that the prevailing wind direction may be used as an indicator to determine the largest gradient of concentrations of pollutants in precipitation.

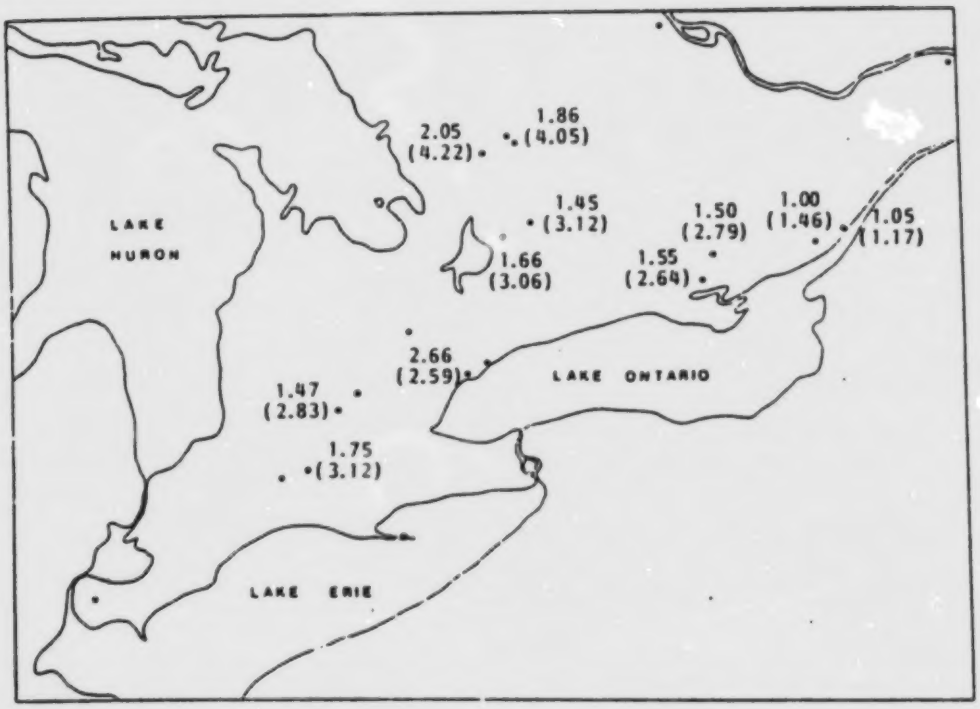


FIGURE 8

AVERAGE CONCENTRATIONS, mg/ℓ, OF $SO_4^{=}$ AND NO_3^{-} (IN BRACKET) FOR PRECIPITATION EPISODE 1, FEBRUARY 1 TO 3, 1981

4.2 Episode 2: February 10 to 12, 1981

Figures 9 and 10 display the daily and episode average concentrations of $SO_4^=$ and NO_3^- measured in precipitation collected at selected sampling sites in the southern and central Ontario area on February 10-12, 1981. As shown in the figures, the NO_3^- concentrations were slightly higher than the $SO_4^=$ concentrations, on a mass basis, at most sites during this episode. Relatively high concentrations of both $SO_4^=$ and NO_3^- were measured in the southern Ontario region, including the region just north of Lake Ontario, on February 10. The Lake Simcoe and Muskoka region measured the smallest concentrations.

On February 11, the concentrations increased slightly at most sites, with the largest increase occurring in the Lake Simcoe and Muskoka region. The maximum concentrations of $SO_4^=$ and $NO3^-$, recorded throughout this episode, were 2.65 and 3.99 mg/L, respectively. These were measured at the Wellesley Site on February 11. Note that these values were much lower than the maxima measured in Episode 1.

The precipitation during this episode was associated with a well-developed extratropical cyclone which moved in a direction from the southwest to the northeast. The centre of this cyclone was located over the central part of the US on February 10 with a warm front extending through the lower Great Lakes States. The entire region of southern and central Ontario was under the warm frontal precipitation band and experienced southeasterly winds as shown in Figure 9. The southeasterly winds caused a larger concentration gradient in the south to north direction than in the west to east direction.

The centre of the cyclone had moved to the north shore of Lake Huron by February 11. Winds were then from the southwest. The concentrations of $SO_4^=$ and NO_3^- in precipitation decreased faster in the west to east direction than in the south to north direction, a situation similar to that in Episode 1.

4.3 Episode 3: February 22 to 24, 1981

The daily and episode average $SO_4^=$ and NO_3^- concentrations in the precipitation collected over southern and central Ontario during this episode are displayed in Figures 11 and 12. It can be seen that the highest concentrations of both $SO_4^=$ and NO_3^- were measured in the southern Ontario region while the lowest concentrations were measured in the region northeast of Lake Ontario. Concentrations of both species decreased much faster in a west to east direction than in a south to north direction. On a mass basis, the $SO_4^=$ concentrations were slightly higher than the NO_3^- concentrations on February 23.

The reverse was observed on February 24. The $SO_4^=$ concentrations were of the same magnitude at the southern Ontario and Lake Simcoe and Muskoka sites on February 24. However, the NO_3^- concentrations increased from the southern Ontario sites to the Lake

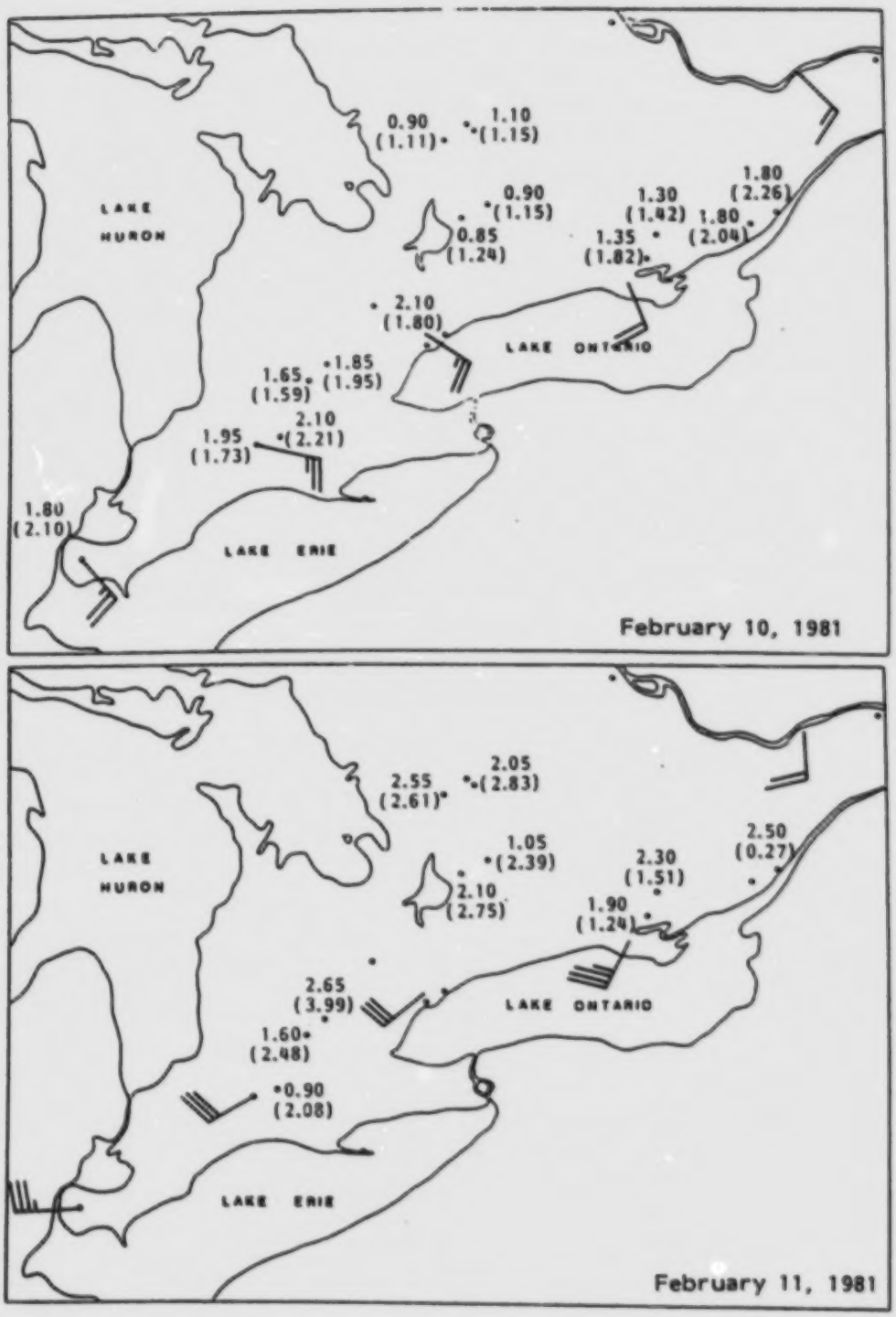


FIGURE 9

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 2, FEBRUARY 10 to 12, 1981

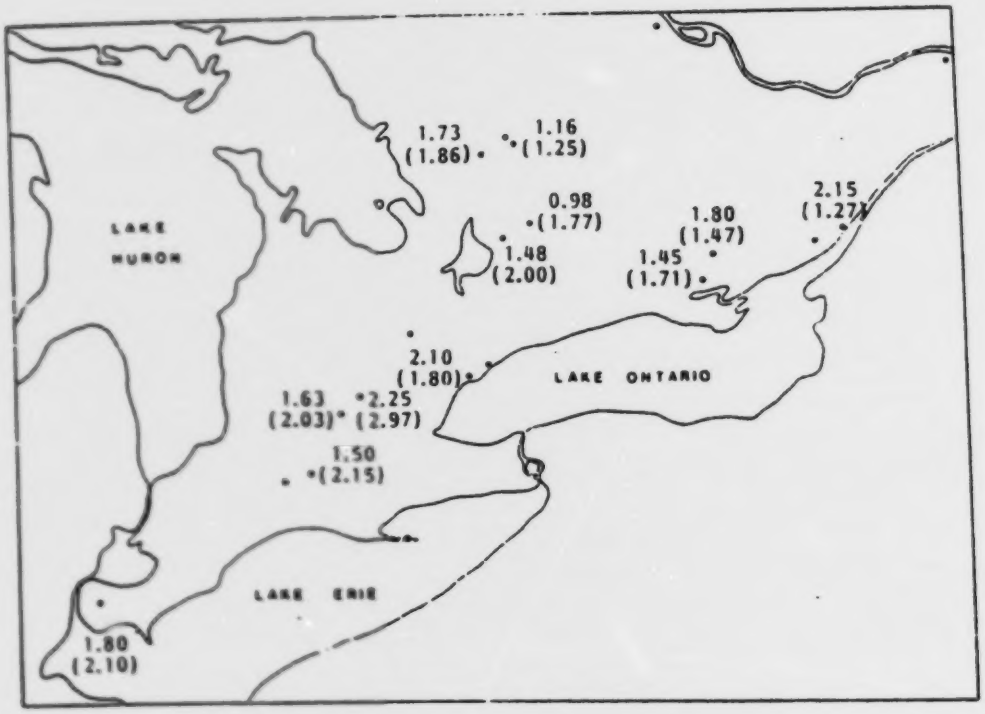


FIGURE 10

AVERAGE CONCENTRATIONS, mg/ℓ, OF $SO_4^{=}$ AND NO_3^{-} (IN BRACKET) FOR PRECIPITATION EPISODE 2, FEBRUARY 10 TO 12, 1981

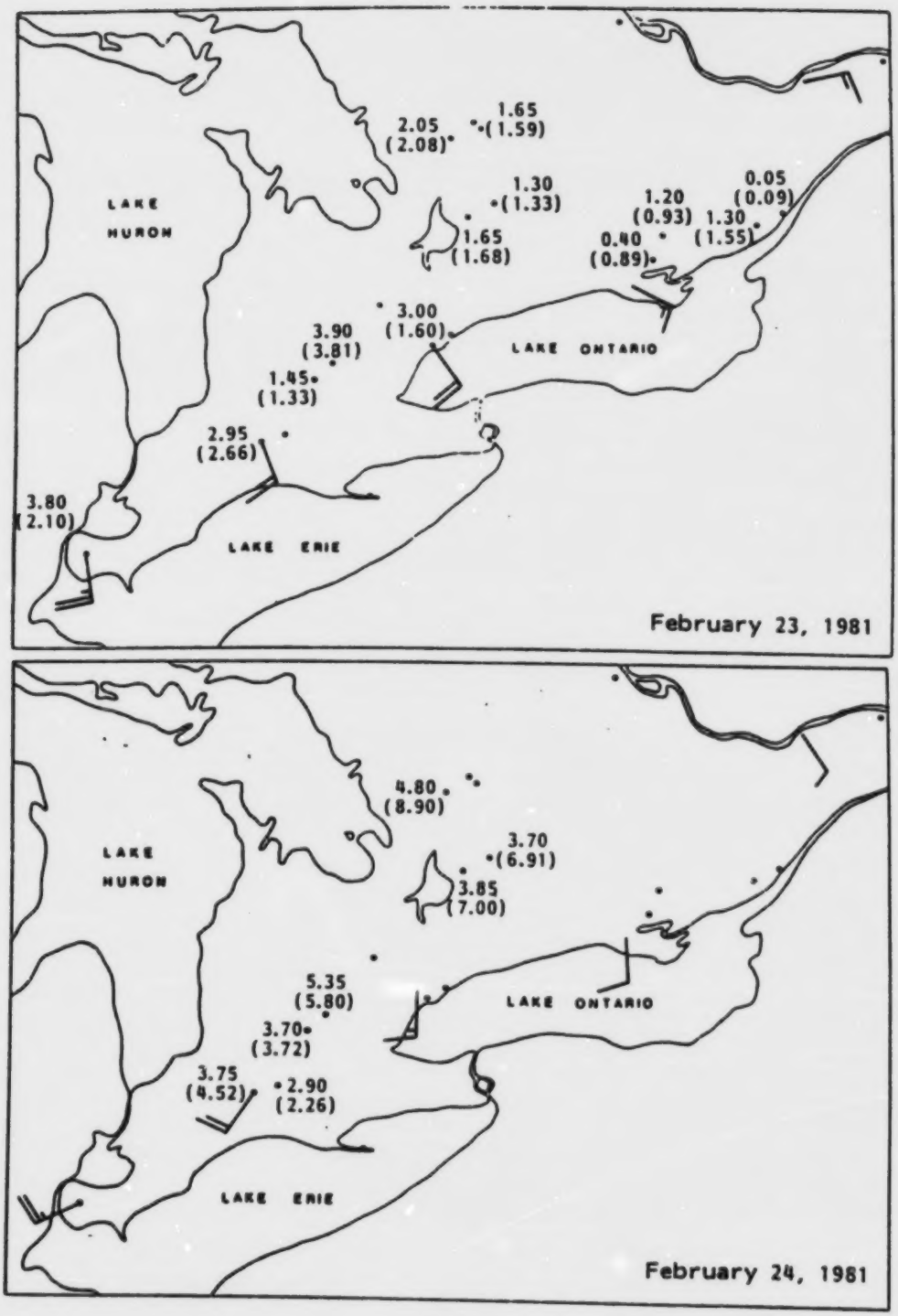


FIGURE 11

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 3, FEBRUARY 22 to 24, 1981

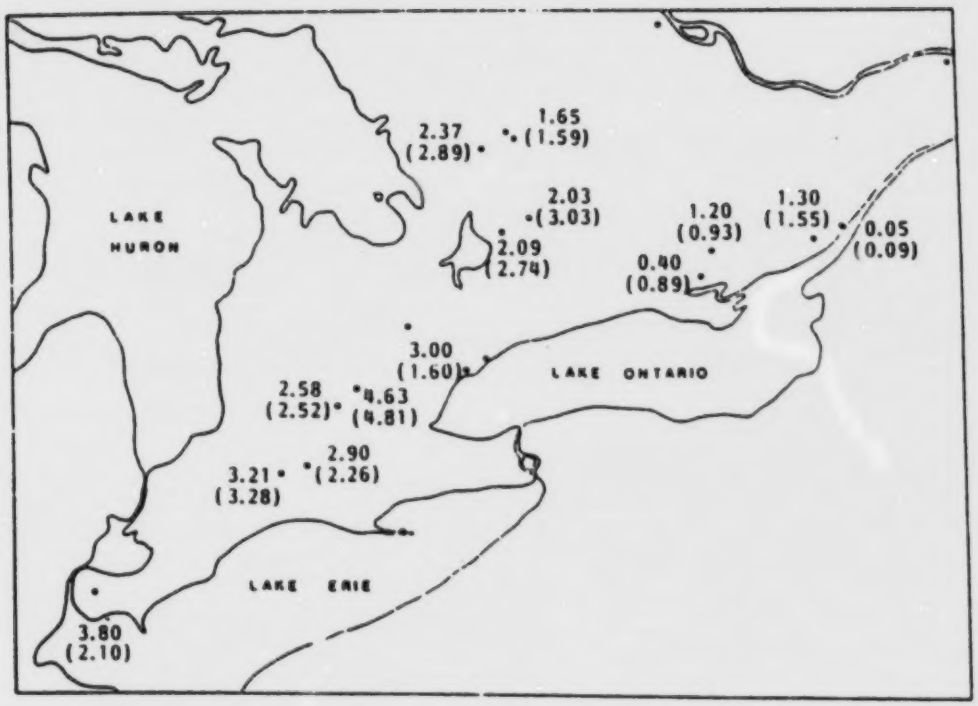


FIGURE 12

AVERAGE CONCENTRATIONS, mg/ℓ , OF $SO_4^{=}$ AND NO_3^{-} (IN BRACKET) FOR PRECIPITATION EPISODE 3, FEBRUARY 22 TO 24, 1981

Simcoe and Muskoka sites by as much as two times. Concentrations of both species were higher on February 24 than on February 23, especially in the Lake Simcoe and Muskoka region where the NO_3^- concentrations were about 4 times larger on February 24 than on February 23.

As discussed in Section 3, this episode was generated by frontal disturbances passing over the upper Great Lakes area and the development of a squall line. The warm front extending through Lakes Huron and Nipissing to Quebec caused southeasterly flows over the sampling area on February 23. However, the presence of a squall line located over the central Ontario area produced convergence of the southerly winds. Winds were southwesterly in areas near the squall line as can be seen in Figure 11. Thus, the gradient of $SO_4^=$ and NO_3^- concentrations was rather large in a direction from the southwest to the northeast. Concentrations measured in the region north of Lake Ontario on this day may have been low because air was advected from the relatively clean New England area.

By February 24, the warm front had moved out of the Ontario area and the squall line had dissipated. The sampling area was then under the influence of a cold front system, which stretched southeastward from the north shore of Lake Superior. Southwesterly winds predominated. However, the increase in concentrations in a northward direction was not clear on this day.

4.4 Episode 4: May 9 to 12, 1981

Figures 13 and 14 display the daily and episode average $SO_4^=$ and NO_3^- concentrations in precipitation collected over the southern and central Ontario area during this episode. Again, the $SO_4^=$ concentrations were higher than the NO_3^- concentrations, on a mass basis. Concentrations were high on May 9 and decreased thereafter until May 11. An increase in concentrations was observed on May 12, especially in the region north of Lake Ontario. Figures 13 and 14 also show that the highest $SO_4^=$ concentrations were measured in the southern Ontario region, with a maximum of 14.5 mg/L being observed at the Melbourne Site on May 9. The $SO_4^=$ concentrations decreased northward and eastward from this area. The minimum of 1.15 mg/L was measured at the Graham Lake Site on May 11.

The highest NO_3^- concentrations were measured in the Lake Simcoe and Muskoka region with a maximum of 7.13 mg/L being observed at the Nithgrove Site on May 9. The concentrations decreased southward and eastward on May 9 and May 10. On May 11, the higher concentrations of NO_3^- were in the regions of southern Ontario and north of Lake Ontario. Conversely, the concentrations in the Lake Simcoe and Muskoka region were the lowest. The minimum of 0.31 mg/L was measured at the Dorset Site on May 12.

The precipitation during this episode was initially generated by a trough developed between two high pressure systems and later by frontal disturbances associated with a well-developed

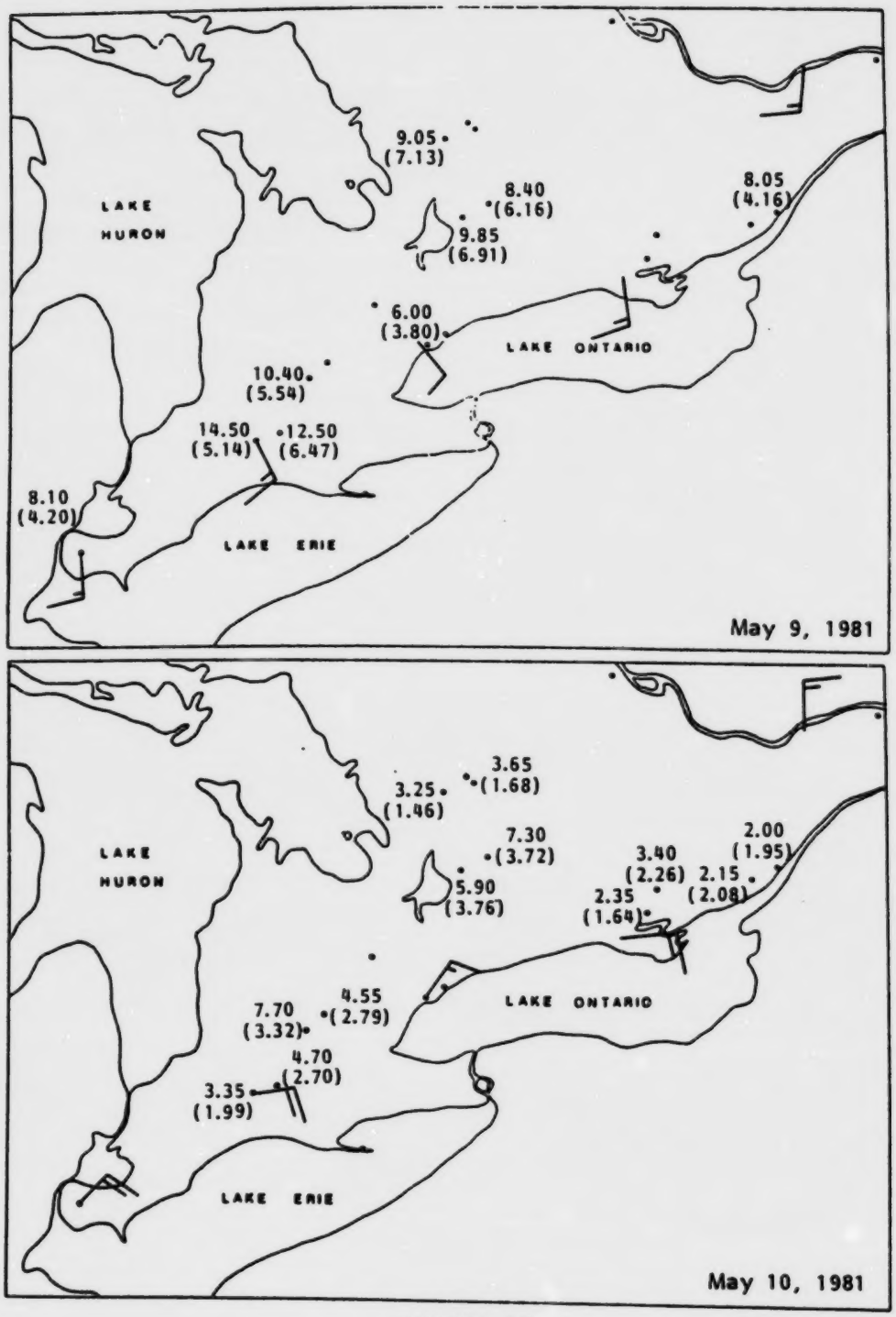


FIGURE 13

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 4, MAY 9 to 12, 1981

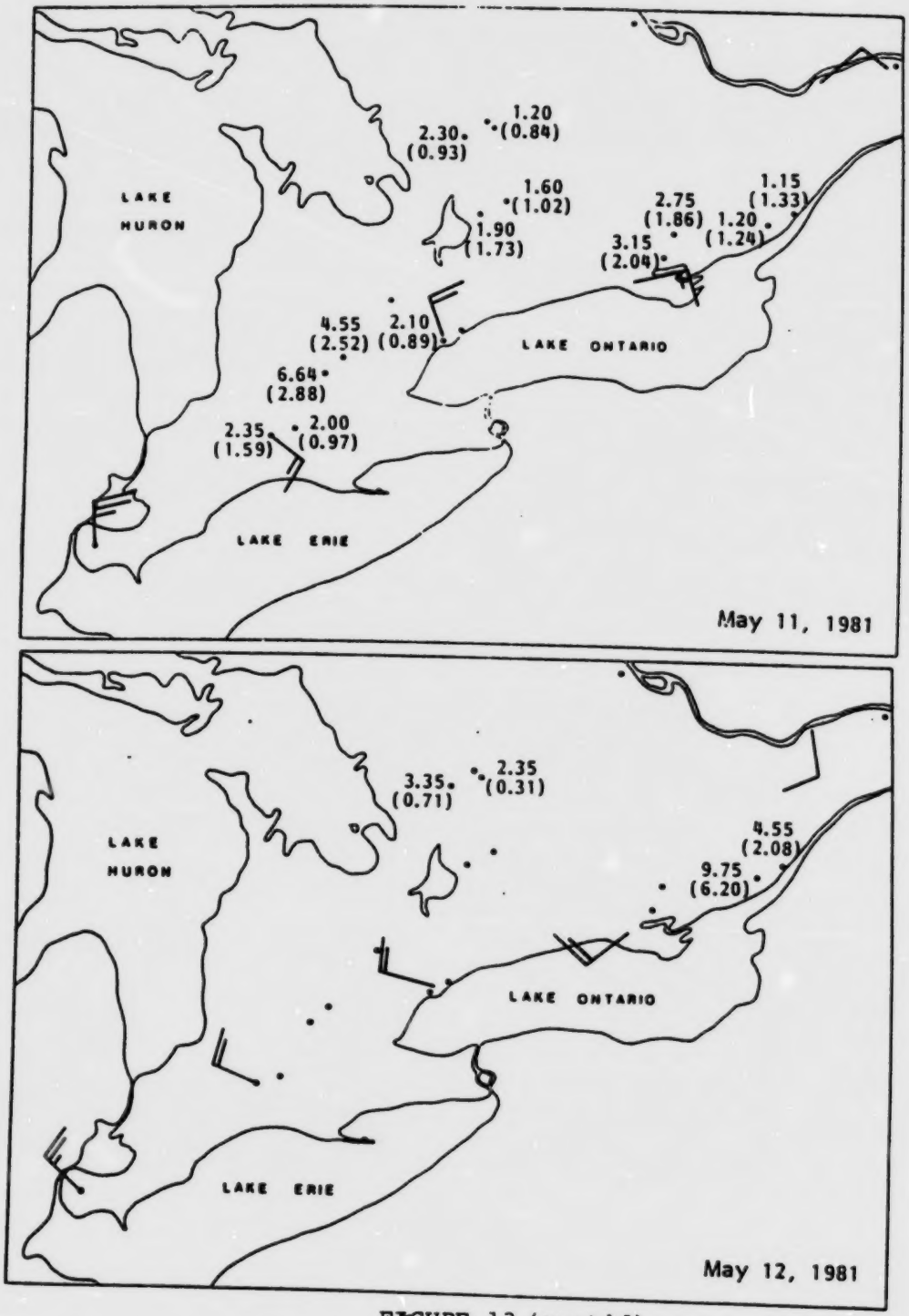


FIGURE 13 (cont'd)

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 4, MAY 9 to 12, 1981

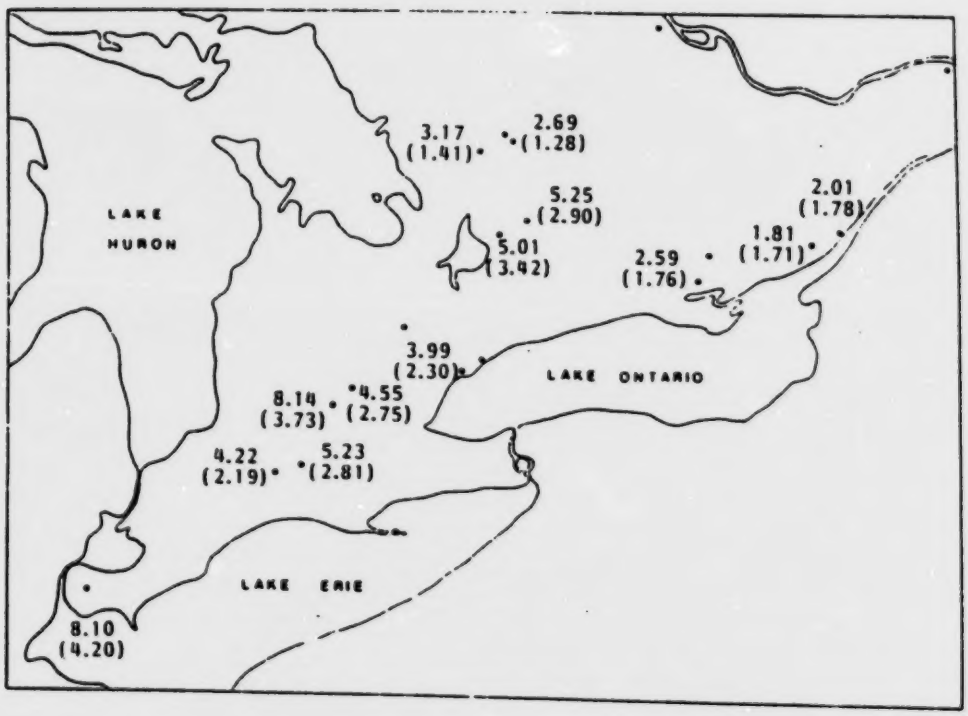


FIGURE 14

AVERAGE CONCENTRATIONS, mg/ℓ , OF $SO_4^{=}$ AND NO_3^{-} (IN BRACKET)
FOR PRECIPITATION EPISODE 4, MAY 9 TO 12, 1981

extratropical cyclone. The trough was located over the east shore of Lake Huron on May 9, causing southwesterly flows over the sampling area. The concentration gradient was consistent with the wind direction as can be seen in Figure 13.

On May 10, the weather over Ontario was under the influence of a strong high pressure system to the north and a warm front to the south. Northeasterly winds predominated in the sampling area. The northern component of the winds was still apparent on May 11. However, winds began to change to westerly in the afternoon of May 11 when the extratropical cyclone moved to the east coast through the lower Great Lakes States. The low concentrations of $SO_4^=$ and NO_3^- at the Lake Simcoe and Muskoka region on May 11 and 12 may be attributed to the transport of clean arctic air by the northerly winds.

4.5 Episode 5: August 28 to 31, 1981

The daily and episode average $SO_4^=$ and NO_3^- concentrations in the precipitation collected over the southern and central Ontario area during this episode are displayed in Figures 15 and 16. As shown in the figures, the concentrations of $SO_4^=$ were much higher than those of NO_3^-, on a mass basis. Higher concentrations were measured in the southern Ontario region on August 28. However, the zone of highest concentrations shifted to the Lake Simcoe and Muskoka region on August 29 and 30; and on August 31, it was in the region north of Lake Ontario.

More specifically, the highest concentrations in regions of southern Ontario and north of Lake Ontario occurred on August 28. The maximum concentrations of $SO_4^=$ and NO_3^- were 14.50 mg/L, measured at the North Easthope Site, and 8.10 mg/L, measured at the Railton Site, respectively. Concentrations of both species then decreased until August 31; thereafter, the concentrations began to increasse.

In the region of Lake Simcoe and Muskoka, the highest concentrations occurred on August 29. The maximum $SO_4^=$ and NO_3^- concentrations were 19.90 and 6.95 mg/L, respectively. Both maxima were measured at the Dorset Site.

As described in Section 3, the precipitation in this episode was generated by warm frontal disturbances and a blocking high pressure system. On August 28, the weather over Ontario was controlled by a high pressure system centered in the Nipissing area. Easterly to northeasterly winds predominated.

By August 29, the high pressure system had moved to the New England States and a warm front was located across southern Ontario. Winds were easterly in areas north of the front and southerly in areas behind the warm front, as can be seen in Figure 15. The high concentrations measured in the Lake Simcoe and Muskoka region may be attributed to the southerly winds which no doubt transported polluted air to the sampling area.

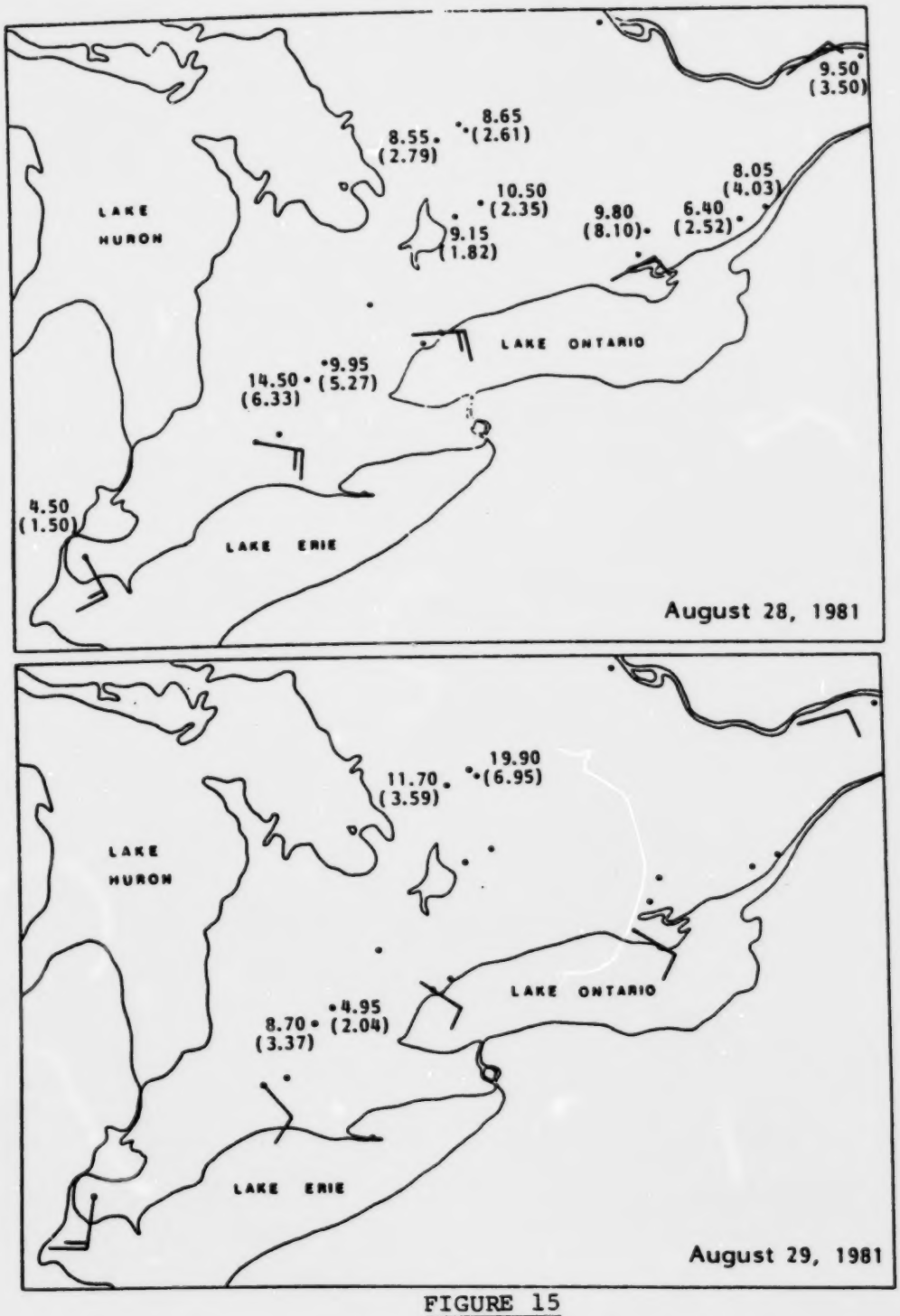


FIGURE 15

DAILY AVERAGE CONCENTRATIONS, mg/L, of $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 5, AUGUST 28 to 31, 1981

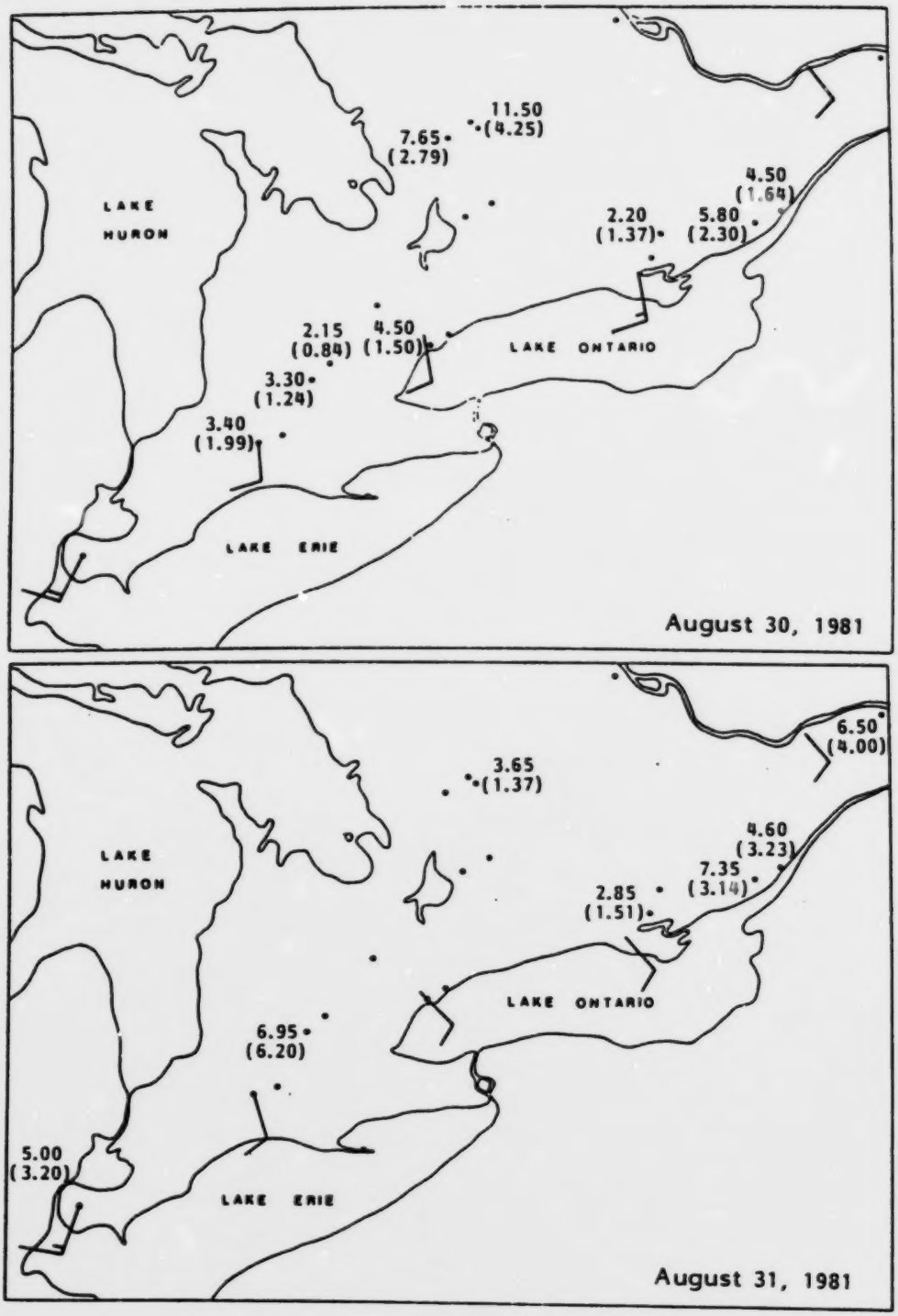


FIGURE 15 (cont'd)

DAILY AVERAGE CONCENTRATIONS, mg/L, OF $SO_4^=$ AND NO_3^- (IN BRACKET) FOR PRECIPITATION EPISODE 5, AUGUST 28 to 31, 1981

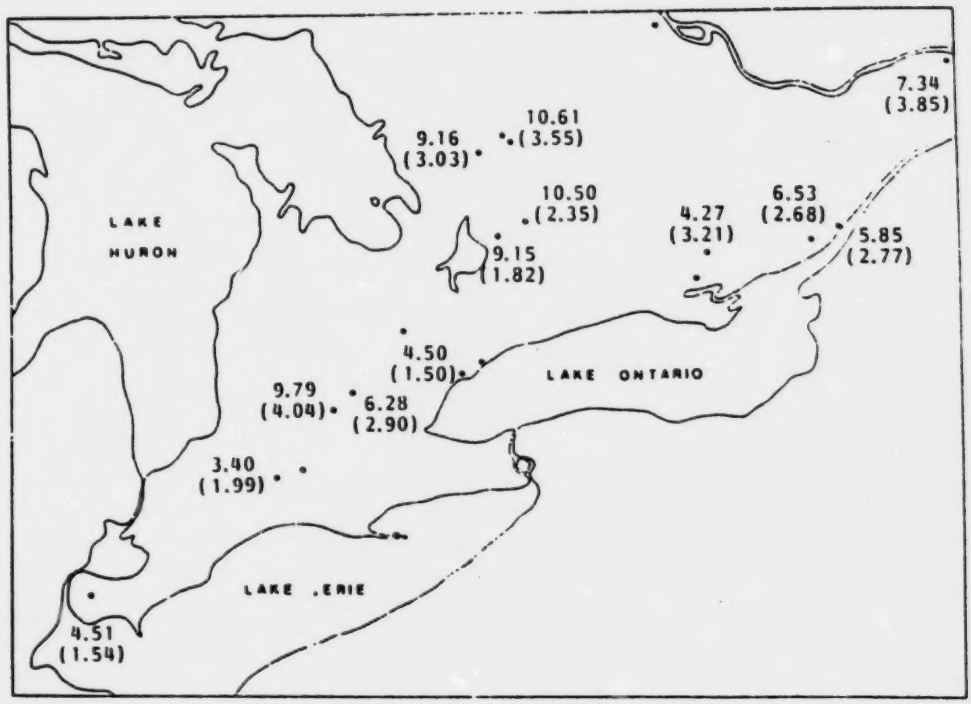


FIGURE 16

AVERAGE CONCENTRATIONS, mg/ℓ , OF $SO_4^{=}$ AND NO_3^{-} (IN BRACKET)
FOR PRECIPITATION EPISODE 5, AUGUST 28 TO 31, 1981

The southerly winds persisted through the end of the episode. Also, during this period, the warm front weakened and a strong high pressure system re-established off the New England coast. This high drove relatively cleaner New England air to the Ontario area and this produced lower concentrations of $SO_4^=$ and NO_3^- on August 30 and 31.

5.0 DISCUSSION OF RESULTS

The preceding sections have described the synoptic meteorological patterns and the distributions of $SO_4^=$ and NO_3^- concentrations for five precipitation episodes observed in Ontario in 1981. The likely relationships between precipitation chemistry and weather conditions were also discussed. This section attempts to identify an acid precipitation climatology based on the above analyses.

Table VII illustrates the average precipitation data, $SO_4^=$ and NO_3^- concentrations and synoptic weather conditions for each precipitation episode. It is useful to recall here that the five episodes being studied were February 1 to 3; February 10 to 12; February 22 to 24; May 9 to 12 and August 29 to 31, 1981. These five episodes provide examples of situations in winter, spring and summer.

The results in Table VII show that the $SO_4^=$ and NO_3^- concentrations were greatest in the summer and least in the winter, although sulfate concentrations show a larger seasonal variation. Precipitation amount and rate was significantly higher in the spring and summer episodes. The $SO_4^=$ and NO_3^- concentrations followed the same pattern.

It is also seen from the table that the $SO_4^=$ concentrations and precipitation rate increased at the same rate. Both increased about eight times from Episode 1 to Episode 5. On the other hand, the NO_3^- concentrations increased only 2.5 times in going from Episode 1 to 5.

Most precipitation in winter occurred as snow and snow showers while those in spring and summer occurred as rain and rain showers. The data indicate that the NO_3^- concentrations were larger than the $SO_4^=$ concentrations, on a mass basis, in episodes when precipitation was in the form of snow. The opposite was observed when precipitation was in the form of rain.

The predominant synoptic weather types during these five episodes included warm fronts, cold fronts, squall lines and extratropical cyclones and anticyclones. The latter two were associated with frontal developments. From the meteorological point of view, warm frontal precipitation usually extends over a broader area, lasts longer and is less intensive than cold frontal precipitation. Squall line precipitation is very heavy and has associated thunderstorms. These storms tend to be very brief.

TABLE VII

THE AVERAGE PRECIPITATION DATA, $SO_4^=$ AND NO_3^- CONCENTRATIONS AND SYNOPTIC WEATHER CONDITIONS FOR THE FIVE PRECIPITATION EPISODES

	Episode 1 Feb 1-2	Episode 2 Feb 10-12	Episode 3 Feb 22-24	Episode 4 May 9-12	Episode 5 Aug 28-31
Averaged Precipitation Amount (mm)	12.1	32.64	19.75	35.9	42.5
Averaged Precipitation Duration (h)	31	34.6	32	46.6	14.2
Averaged Precipitation Rate (mm/h)	0.39	0.94	0.62	1.30	3.00
Precipitation Type	Snow	Snow & snow showers	Rain & rain showers	Rain & rain showers	Rain & rain showers
Averaged $SO_4^=$ (mg/L)	3.32	3.42	4.50	16.0	25.17
Averaged NO_3^- (mg/L)	5.06	4.11	5.28	9.33	12.64
Synoptic Weather Type	Warm Front	Extra-tropical Cyclone	Squall Line & Cold Front	Pre-frontal Trough & Anticyclone	Warm Front & Anti-cyclone
Averaged Surface Wind Direction	S SW	S W	SE SW	SW E	E SE S

In the present study, warm frontal precipitation contributed the highest $SO_4^=$ and NO_3^- concentrations. As shown in Episode 1, for example, the concentration gradient in the south to north direction, due to a warm front on February 1 was about 20% larger than the gradient in the west to east direction due to a cold front on February 2.

During these five episodes, most precipitation occurred with southerly winds and a fraction with easterly winds. The precipitation chemistry data indicated that concentrations of both $SO_4^=$ and NO_3^- responded to these wind direction patterns very closely.

In summary, precipitation containing acidic pollutants such as $SO_4^=$ and NO_3^-, can occur in the summer season when a cyclone with warm front development is located over the upper Great Lakes area. Precipitation can also occur when an anticyclone is located over the New England and Maritime Provinces area. Both conditions produce southerly winds in the Ontario region. Further, if the New England and Maritime Provinces high pressure systems move northward to the Quebec and Labrador areas, winds shift to easterly, over the Ontario region. In this case, warm and moist air can be driven into the Ontario region from the east coast and produce heavy precipitation. However, the $SO_4^=$ and NO_3^- concentrations would have peaked with southerly winds since the emission density is higher in these upwind regions.

6.0 CONCLUDING REMARKS

This report summarizes synoptic meteorological conditions and distributions of $SO_4^=$ and NO_3^- concentrations for five precipitation episodes over Ontario in 1981. Synoptic conditions included in these five episodes are cyclones with frontal development moving into the study area from the southwest; anticyclones with or without frontal development located to the northeast of the study area; and squall lines, including pre-frontal troughs. Among these synoptic conditions, cyclones with warm fronts dominated the precipitation patterns.

The distributions of $SO_4^=$ and NO_3^- concentrations indicated strong dependence of these species on the precipitation rate and amount. The concentrations were greatest in the summer and least in the winter. As might be expected, warm frontal precipitation contributed the highest concentrations in the sampling area due partly to its longer duration and partly to the associated southerly winds. Additionally, the $SO_4^=$ concentrations were higher than the NO_3^- concentrations, on a mass basis, when the precipitation was in the form of rain but the reverse was true when the precipitation was in the form of snow.

Wind directions played a significant role in determining the spatial gradient of concentrations. The gradient was in the direction of the prevailing winds. The largest gradient occurred in southerly and easterly winds.

While a great deal of precipitation chemistry data have been collected in Ontario and vicinity, the results presented here are still preliminary and deficient. It is apparent that this and other similar efforts which have attempted to systematize observed data into an "acid rain climatology", have failed to quantitatively describe the processes responsible for the large spatial and temporal variability in concentrations, seasonal changes in the sulfur to nitrogen ratio, etc. It is hoped that modelling studies of the physical and chemical processes in clouds now underway, will provide better means of exploring these processes.

Approved by:

O.A. Kupcis
Manager
Chemical Research Department

YTT/mf

Prepared by:

Y.T. Tam
Atmospheric Physicist
Atmospheric Research Section

Reviewed by:

O.T. Melo
Supervising Engineer
Atmospheric Research Section

REFERENCES

BARRIE, L.A., H.A. Wiebe, P. Fellin and K. Anlauf, 1981: "Results of the Canadian Air and Precipitation Monitoring Network APN: July, 1979 to June, 1980." AES Report AQRB-81-026-T.

CHAN, W.H., 1983: "Acid Precipitation in Ontario Study - APIOS: Daily Precipitation Chemistry Listing, July 15, 1980 to December 31, 1981." OME Report ARB-19a-82-ARSP.

HANDY, B., 1981: "Upgrading of Ontario Hydro's Air and Precipitation Monitoring Network." Ontario Hydro Research Division Report C81-153-K.

HOBBS, P.V., 1978: "Organization and Structure of Clouds and Precipitation on the Mesoscale and Microscale of Cyclonic Storms." Rev. Geophys. Space Phys., 16, 741-755.

JARV, T., 1982a: "Ontario Hydro Air, Aerosol and Precipitation Monitoring Network Assessment and Upgrading." Ontario Hydro Research Division Report 82-484-K.

JARV, T., 1982b: "Acid Rain Studies at Ontario Hydro: Air, Aerosol and Precipitation Chemistry Measurements for 1981." Ontario Hydro Research Division Report C82-81-K.

JARV, T., 1983: "Statistical Analysis of Ontario Hydro's Precipitation Chemistry Data." Ontario Hydro Research Division Report 83-201-K.

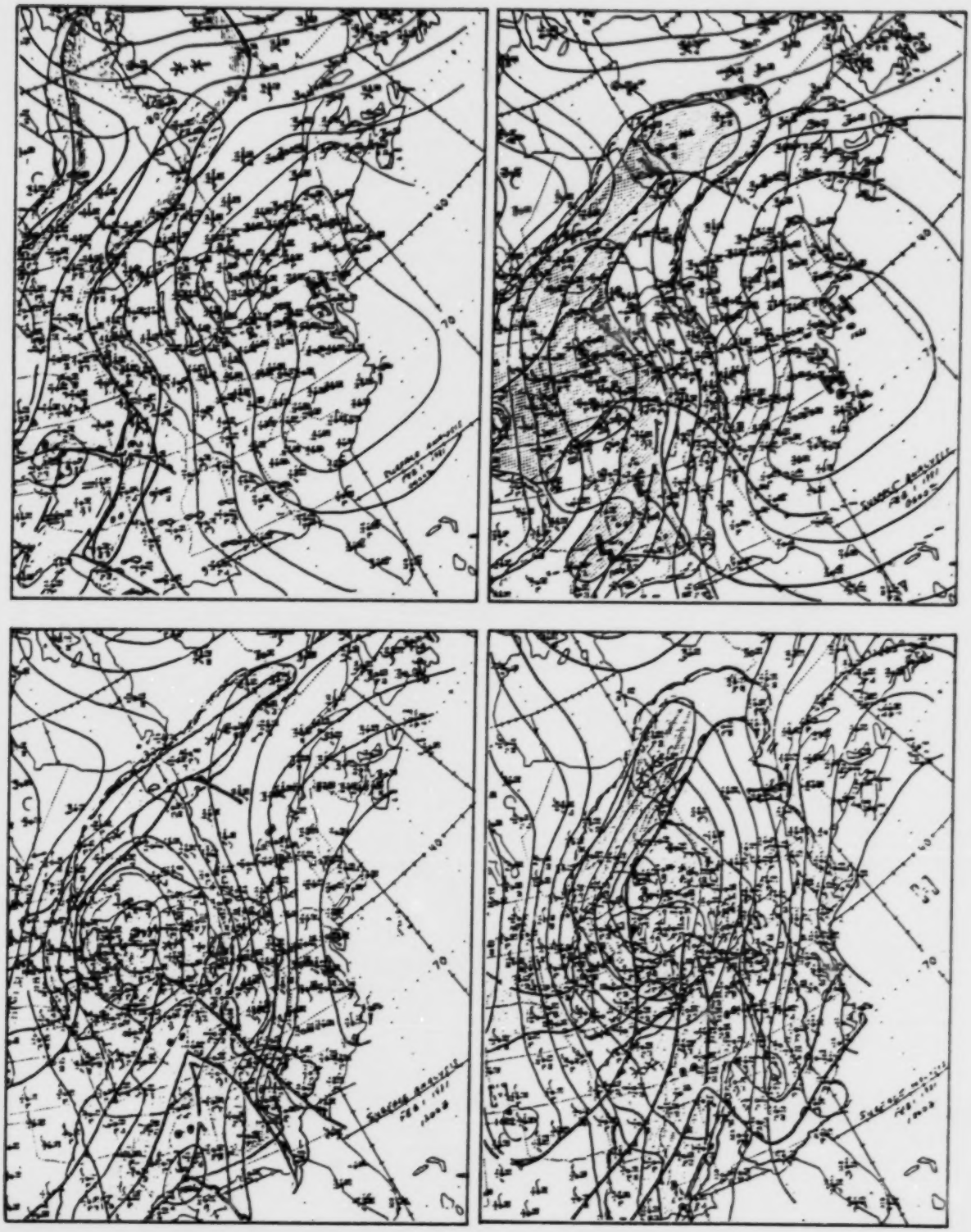
KURTZ, J., A.J.S. Tang, R.W. Kirk and W.H. Chan, 1984: "Analysis of an Acidic Deposition Episode at Dorset, Ontario." Atm. Env., 18, 387-394.

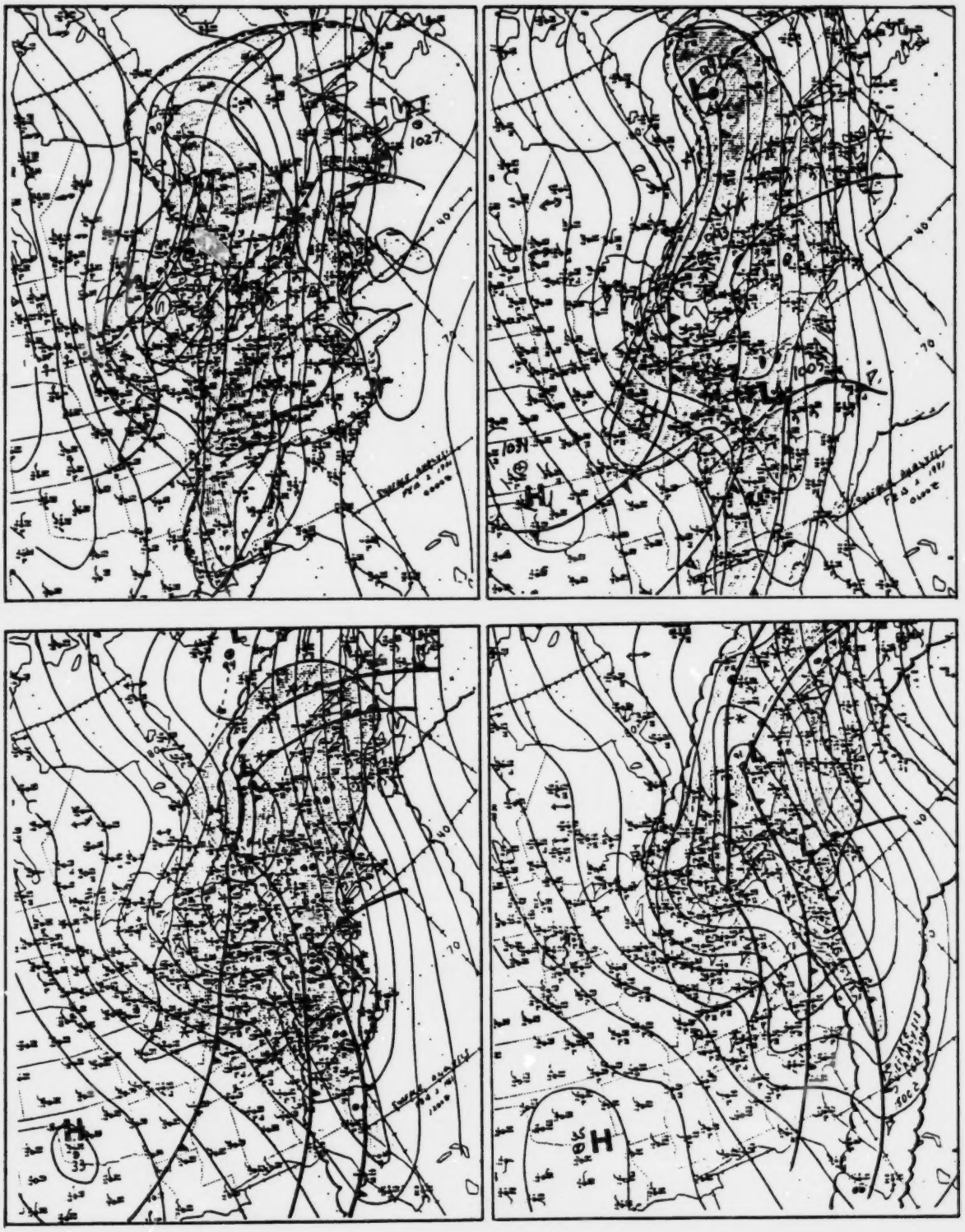
PRESSNAIL, J., 1983: "A Facility for Graphical Display of Synoptic Weather Maps. A User's Guide." Ontario Hydro Research Division Report 83-502-K.

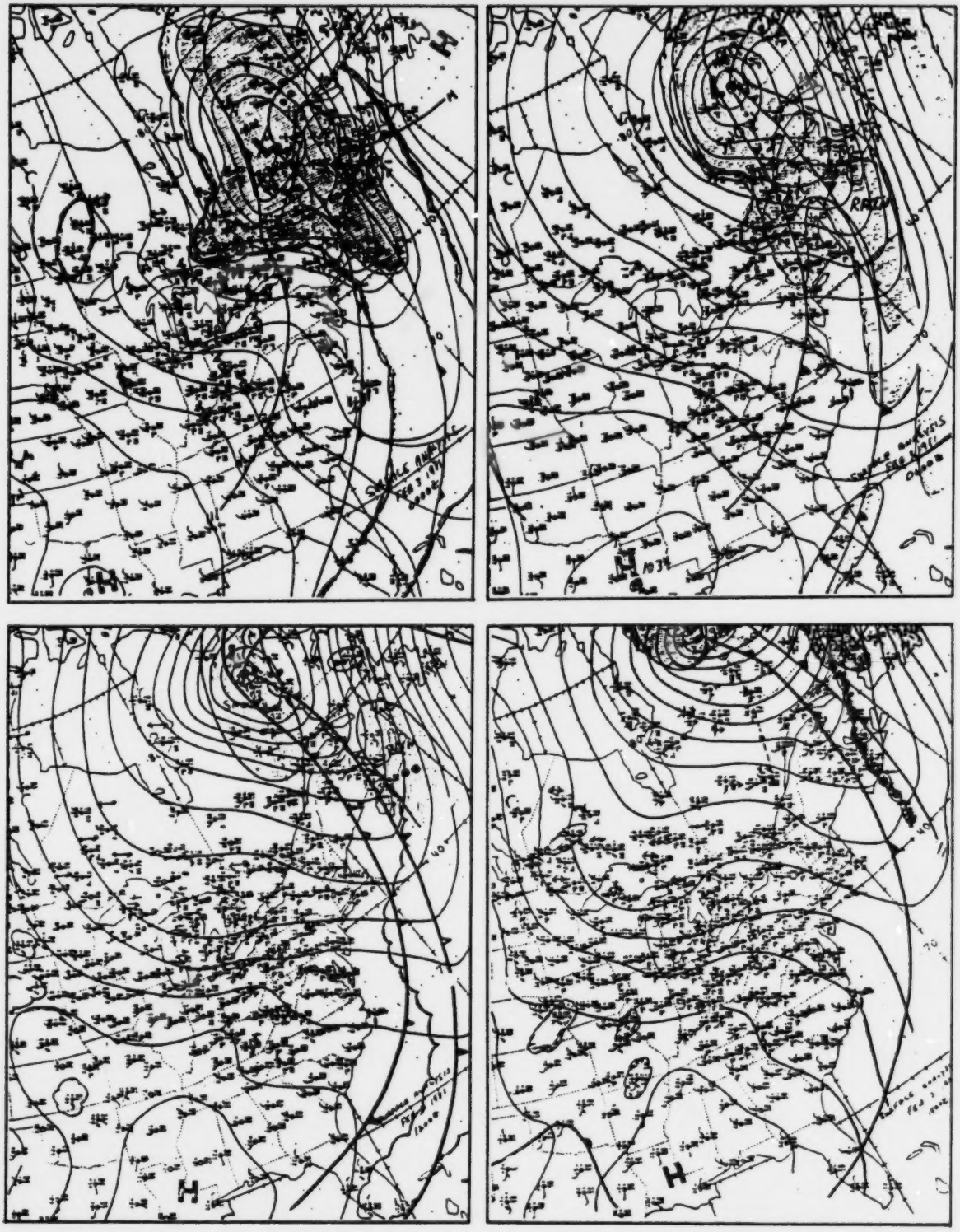
THORP, J.M., and B.C. Scott, 1982: "Preliminary Calculations of Average Storm Duration and Seasonal Precipitation Rates for the Northeast Sector of the United States." Atm. Env., 16, 1763-1774.

APPENDIX A

SURFACE SYNOPTIC WEATHER MAPS AND OBSERVATIONAL DATA FOR PRECIPITATION EPISODE 1: FEBRUARY 1 TO 3, 1981







SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 1, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-99	83	29	15	1021	2	CI(SCT)	270												
1	-96	81	18	15	1019	8	CI(BKN)	270												
2	-82	76	19	19	1017	10	AC(SCT)	100	CI(OVC)	270										
3	-80	74	11	24	1016	10	AC(SCT)	100	CI(OVC)	250										
4	-76	71	11	15	1014	10	AC(SCT)	100	CI(OVC)	250										
5	-65	64	13	19	1012	5	AC(SCT)	100	CI(-SCT)	250										
6	-58	59	14	22	1009	10	AC(SCT)	35	AC(SCT)	100	CI(OVC)	250								
7	-29	51	15	24	1008	10	SC(SCT)	30	AC(BKN)	90	CS(OVC)	220								
8	-17	54	17	19	1008	10	PC	-X)	NS(OVC)	30										
9	-28	78	15	30	1007	10	PC	X)	12											
10	-16	95	17	31	1006	21	PC	X)	8											
11	-17	94	16	33	1006	10	PC	X)	2											
12	-5	91	17	31	1003	10	PC	-X)		ST(OVC)	10									
13	4	96	18	37	1002	10	PC	-X)		ST(OVC)	10									
14	8	96	19	37	1001	10	PC	-X)		ST(OVC)	6									
15	12	94	19	35	1000	10	PC	-X)		ST(OVC)	6									
16	15	94	19	37	1000	5	SF(OVC)	8												
17	18	94	20	31	1001	10	SF(OVC)	8												
18	11	95	19	26	1000	10	PC	-X)		SF(OVC)	5									
19	8	96	19	24	1000	10	PC	-X)		SF(OVC)	5									
20	7	97	20	20	9994	10	PC	-X)		SF(OVC)	5									
21	11	95	20	24	9992	10	SF(OVC)	4												
22	12	96	21	20	9985	10	SF(OVC)	4												
23	12	97	22	20	9980	10	SF(OVC)	3												

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 2, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	8	96	22	19	9984	10	SF(BKN)	4	SF(OVC)	7										
1	4	96	24	15	9975	10	PC	-X)	SF(BKN)	4	SF(OVC)	9								
2	8	92	27	20	9974	10	SF(BKN)	4	SF(OVC)	7										
3	-14	88	25	19	9985	10	SF(SCT)	8	SC(OVC)	15										
4	-16	76	26	28	9988	10	SC(OVC)	29												
5	-21	75	25	15	9984	10	SC(OVC)	29												
6	-21	76	24	17	9985	10	SC(BKN)	19	SC(OVC)	30										
7	-28	79	25	19	9987	10	PC	-X)	SC(OVC)	24										
8	-38	89	23	15	9986	10	PC	X)	10											
9	-41	89	23	24	9984	10	PC	X)	10											
10	-51	87	23	31	9985	10	PC	X)	10											
11	-52	87	23	35	9989	10	PC	X)	10											
12	-59	86	28	33	10000	10	PC	X)	10											
13	-68	84	29	28	10012	9	PC	-X)		CU(BKN)	12	SC(BKN)	30								1
14	-76	75	27	39	10023	5	CU(SCT)	12		SC(SCT)	50										1
15	-82	72	26	29	10037	9	CU(SCT)	15		SC(BKN)	32										1
16	-83	71	28	38	10047	9	PC	-X)		CU(BKN)	17										1
17	-91	70	28	29	10055	9	PC	-X)		CU(BKN)	15										1
18	-96	78	27	22	10066	7	SC(BKN)	20													
19	-101	74	27	19	10081	10	PC	-X)		SC(OVC)	20										1
20	-105	69	25	24	10086	5	SC(SCT)	25													
21	-110	70	25	29	10093	4	SC(SCT)	25													
22	-114	73	25	29	10103	4	SC(SCT)	25													
23	-110	70	26	29	10110	10	PC	X)	26												1

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 3, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-125	86	26	22	10116	10	PC	X)	6											1
1	-131	85	25	19	10127	10	PC	X)	6											1
2	-143	81	25	22	10129	4	SC(SCT)	20												1
3	-143	82	23	20	10136	7	PC	-X)												1
4	-145	80	24	22	10140	8	PC	-X)		SC(BKN)	20									1
5	-150	83	24	24	10145	5	PC	-X)		SC(SCT)	20									1
6	-167	82	24	22	10152	4	PC	-X)		SC(SCT)	20									1
7	-171	84	24	20	10161	8														
8	-173	84	23	24	10169	8														
9	-171	83	23	24	10180	8														
10	-162	79	23	22	10180	8	SF(SCT)	16		AC(-SCT)	100									
11	-151	78	23	22	10189	11	CU(SCT)	16												
12	-150	64	23	26	10195	4	CU(SCT)	25		AC(SCT)	100									
13	-143	63	25	26	10198	7	CU(BKN)	25												
14	-139	67	24	28	10198	9	PC	-X)		CU(BKN)	23									1
15	-139	72	24	24	10188	10	PC	-X)		CU(OVC)	22									1
16	-140	69	24	31	10185	7	PC	-X)		CU(BKN)	25									1
17	-142	65	23	31	10189	5	CU(SCT)	25												
18	-150	64	24	31	10194	3	CI(-SCT)	250												
19	-154	66	23	28	10202	4	SC(SCT)	25		CI(-SCT)	250									
20	-154	66	23	29	10209	3	SC(SCT)	40												
21	-154	66	23	30	10209	3	SC(SCT)	30												
22	-153	65	23	28	10197	4	SC(SCT)	40												
23	-152	66	23	24	10194	4	SC(SCT)	30												

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 1, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10'S	KM/H	0.01 KPA	10THS														
0	-61	81	12	6	10233	2	CI(SCT)	250												
1	-63	86	13	7	10221	8														
2	-58	87	11	11	10206	8	CI(-BKN)	250												
3	-62	87	11	13	10188	9	CI(BKN)	240												
4	-36	86	13	17	10166	8	CI(BKN)	240												
5	-42	86	14	11	10146	4	AC(SCT)	120	CI(-SCT)	250										
6	-39	75	13	13	10123	8	AC(SCT)	70	CI(-BKN)	250										
7	-35	72	12	15	10102	9	AC(BKN)	90	CI(BKN)	240										
8	-19	77	14	17	10078	9	AC(BKN)	80	AC(BKN)	140	CI(BKN)	240								
9	-18	79	14	19	10048	9	AC(BKN)	80	AC(BKN)	130										
10	-3	67	15	15	10078	10	SC(SCT)	40	AC(OVC)	70										
11	4	55	17	22	10069	10	SC(BKN)	24	AC(OVC)	70										
12	-3	77	17	31	10047	10	PC -X		SC(OVC)	17										
13	-8	94	17	24	10033	10	PC X	4												
14	7	95	19	28	10018	10	SF(OVC)	10												
15	15	93	19	35	10007	10	SF(OVC)	9												
16	28	98	28	35	10013	10	SF(BKN)	9	SC(OVC)	14										
17	28	98	19	35	10007	10	SC(OVC)	13												
18	26	98	28	33	10018	10	SC(OVC)	13												
19	22	92	18	30	10006	10	SC(OVC)	12												
20	21	93	19	26	10007	10	SF(BKN)	11	SC(OVC)	18										
21	20	90	28	30	10004	10	SF(BKN)	11	SC(OVC)	17										
22	17	92	28	24	9992	10	SF(SCT)	7	SC(OVC)	11										
23	14	94	19	22	9993	10	SF(OVC)	8												

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 2, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10'S	KM/H	0.01 KPA	10THS														
0	6	96	17	17	9985	10	SF(BKN)	5	SC(OVC)	15										
1	6	96	17	17	9988	10	SF(BKN)	6	SC(OVC)	15										
2	5	96	18	13	9968	10	SF(BKN)	6	ST(OVC)	15										
3	5	96	28	13	9974	10	SF(SCT)	3	SF(BKN)	5	ST(OVC)	15								
4	6	92	24	19	9978	10	SF(SCT)	5	ST(OVC)	15										
5	3	87	27	28	9973	10	SF(SCT)	13	ST(OVC)	25										
6	-5	87	25	17	9978	10	ST(OVC)	28												
7	-10	79	25	17	9983	10	SF(SCT)	15	ST(OVC)	28										
8	-14	76	26	15	9988	10	SC(OVC)	26												
9	-17	81	24	15	9988	10	SC(BKN)	34	SC(OVC)	50										
10	-20	87	24	19	9988	10	SC(BKN)	40	SC(OVC)	48										
11	-20	83	22	15	9979	10	SF(SCT)	16	SC(OVC)	45										
12	-34	96	29	19	9973	10	PC X	2												
13	-40	92	22	39	9969	10	PC -X		SF(OVC)	12										
14	-45	93	28	43	9981	7	PC -X		SF(SCT)	18	CU(SCT)	15								
15	-46	74	26	44	10004	3	CU(SCT)	20												
16	-74	78	26	39	10019	4	CU(SCT)	20												
17	-85	76	26	43	10033	3	CU(SCT)	25	CI(SCT)	230										
18	-98	78	27	28	10051	3	CU(SCT)	24	CI(-SCT)	240										
19	-103	83	27	26	10063	3	CI(-SCT)	240												
20	-106	85	26	24	10079	0														
21	-113	88	26	9	10078	0														
22	-117	82	26	4	10088	0														
23	-123	77	26	6	10092	0														

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 3, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10'S	KM/H	0.01 KPA	10THS														
0	-128	67	26	9	10182	0														
1	-133	69	26	7	10168	0														
2	-136	71	26	11	10113	0														
3	-145	65	27	15	10128	0														
4	-150	67	24	7	10128	0														
5	-155	78	0	0	10133	0														
6	-160	78	0	0	10138	0														
7	-155	78	22	6	10147	1	CU(SCT)	20												
8	-158	75	24	7	10152	1	CU(SCT)	20	AC(SCT)	90										
9	-148	73	24	19	10164	1	CU(SCT)	25												
10	-135	64	25	31	10167	2	CU(SCT)	25												
11	-135	67	24	37	10172	2	CU(SCT)	30												
12	-130	68	25	39	10174	4	CU(SCT)	30	AC(SCT)	140	CI(SCT)	260								
13	-129	64	25	33	10176	5	CU(SCT)	30	CI(SCT)	230										
14	-134	76	24	24	10177	8	CU(BKN)	25												
15	-125	73	25	28	10176	8	CU(BKN)	22	SC(BKN)	48										
16	-120	81	25	28	10183	9	CU(BKN)	23	AC(BKN)	150										
17	-125	88	27	11	10186	4	CU(SCT)	22												
18	-137	79	24	17	10193	3	CU(SCT)	24	CI(-SCT)	240										
19	-142	85	23	17	10198	4	CU(SCT)	23	CI(-SCT)	240										
20	-146	88	23	15	10199	8														
21	-150	83	24	17	10197	1	CI(SCT)	250												
22	-151	88	25	9	10196	2	CU(SCT)	22	CI(-SCT)	250										
23	-153	79	22	17	10193	3	CI(-SCT)	240												

SURFACE WEATHER OBSERVATION AT TRENTON ON FEBRUARY 1, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	(LCL)		(10'S KTS)	(KTS)	(MB) EPA	(10THS)		(00 FT)		(00 FT)		(00 FT)								
0	-70	80	11	7	1018	6	SC	25	CI	250										
1	-60	91	7	11	1018	3	SC	25	CI	250										
2	-80	72	5	11	1023	2	SC	25	CI	250										
3	-100	91	7	7	1022	4	SC	25	CI	250										
4	-100	91	7	7	1020	8	SC	25	CI	250										
5	-70	84	8	11	1018	4	SC	25	CI	250										
6	-50	75	12	15	1016	4	SC	25	AC	90	CI	250								
7	-40	67	11	11	1015	9	SC	25	AC	100	CI	250								
8	-30	71	12	17	1013	7	AC	80	AC	100	CI	250								
9	-20	68	12	19	1012	10	AC	80	AC	110	CI	250								
10	-10	68	15	13	1012	10	SC	30	AC	80	AC	120								
11	-10	65	14	24	1018	10	SC	30	AC	120										
12	0	63	17	28	1018	10	SC	30	AC	120										
13	-7	88	16	22	1087	10	SC	20												
14	-5	76	16	28	1085	10	SC	25	AC	100										
15	5	73	18	24	1084	10	SC	20	SC	23										
16	15	73	17	26	1086	10	SC	20												
17	10	73	17	31	1084	10	SC	20												
18	17	81	17	22	1083	10	SC	19												
19	20	89	17	19	1083	10	SC	24												
20	17	88	18	15	1083	10	SF	9	SC	20										
21	20	87	17	19	1082	10	SF	11	SC	26										
22	24	91	18	22	1082	10	SF	12	SC	22										
23	25	87	18	19	1081	10	SC	17												

SURFACE WEATHER OBSERVATION AT TRENTON ON FEBRUARY 2, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	(LCL)		(10'S KTS)	(KTS)	(MB) EPA	(10THS)		(00 FT)		(00 FT)		(00 FT)								
0	20	98	18	17	1089	10	SC	17												
1	23	92	18	17	9992	10	SC	16												
2	22	89	17	15	9987	10	SF	5	SC	15										
3	21	93	18	17	9982	10	SF	5	SC	12										
4	25	94	19	17	9974	10	SF	5	SF	8	ST	11								
5	25	94	22	22	9975	10	SF	5	SF	8	ST	11								
6	20	96	23	22	9969	10	SF	5	SF	7	SC	12								
7	9	97	22	22	9966	10	SF	3	SF	6	SC	12								
8	5	96	23	20	9970	10	PI	-3	SF	3	SF	6								
9	6	96	22	19	9970	10	SF	6	SC	14										
10	9	87	24	22	9966	9	SC	24	SC	48										
11	4	92	22	19	9970	10	SC	12	SC	48										
12	6	76	24	41	9966	10	SC	16	SC	48										
13	-12	97	23	33	9968	10	PI	-3	SF	5										
14	-15	69	23	52	9963	7	SC	48												
15	-32	95	23	48	9968	10	PI	-3	SF	5	CC	28								
16	-28	93	24	41	9976	10	SC	15	SC	20										
17	-45	75	27	37	1000	10	SC	25	AC	100										
18	-55	79	25	46	1002	8	SC	30												
19	-75	61	25	41	1004	7	SC	30	CI	250										
20	-82	64	27	38	1005	6	SC	30	CI	250										
21	-92	61	26	41	1006	3	SC	30	CI	250										
22	-101	66	26	38	1008	2	CI	250												
23	-106	79	26	22	1008	75	8													

SURFACE WEATHER OBSERVATION AT TRENTON ON FEBRUARY 3, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	(LCL)		(10'S KTS)	(KTS)	(MB) EPA	(10THS)		(00 FT)		(00 FT)		(00 FT)								
0	-100	76	26	20	1008	8														
1	-115	74	26	20	1008	8														
2	-127	77	30	15	1009	9														
3	-141	77	29	13	1010	9														
4	-150	79	29	11	1011	9														
5	-157	80	30	15	1012	9														
6	-163	67	30	9	1013	9														
7	-170	76	29	7	1014	9	SC	25	CI	250										
8	-175	66	32	11	1015	9	SC	30	AC	100	CI	250								
9	-180	80	29	19	1017	9	SC	30	AC	100	CI	250								
10	-155	67	32	28	1016	9	SC	25	CI	250										
11	-135	67	29	22	1016	9	CU	20	SC	25	CI	240								
12	-120	61	28	28	1016	9	CU	22	CI	240										
13	-115	62	32	28	1016	9	CU	25	CI	240										
14	-115	77	30	33	1016	9	CU	30	AC	100	CI	240								
15	-120	61	29	28	1016	7	CU	22	CI	240										
16	-119	70	28	24	1017	10	CU	20	CI	220										
17	-129	81	27	11	1017	9	CU	20	SC	30	AC	120								
18	-138	62	27	28	1018	9	SC	30	CI	250										
19	-131	62	27	26	1017	9	SC	30	CI	250										
20	-133	79	27	22	1017	9	SC	30	CI	250										
21	-134	73	28	22	1017	9	SC	30												
22	-134	73	29	19	1018	9	SC	35												
23	-138	72	28	22	1018	9	SC	35												

SURFACE WEATHER OBSERVATION AT OTTAWA ON JANUARY 1, 1981

CST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES 0.01 kPa	TOTAL CLD AMT	CLOUDS TYPE	HT 30m	TYPE	HT 30m	TYPE	HT 30m	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	49	91	21	7	10267	7	CU(MEN)	18												
1	93	92	18	4	10258	7	CI(-SCT)	258												
2	100	94	16	4	10253	5	CI(SCT)	258												
3	96	92	18	7	10245	3	CI(-SCT)	258												
4	128	74	27	7	10233	7														
5	134	93	31	9	10224	9	FC (X)													
6	124	94	31	13	10206	6	FC (X)													
7	126	91	31	15	10172	2	FC (X)													
8	120	92	31	17	10173	6	CI(-X)													
9	118	92	31	19	10155	10	AC(SCT)	108	CI(MEN)	258										
10	76	73	31	17	10145	10	AC(SCT)	108	CI(OVC)	258										
11	85	86	31	17	10136	10	AC(SCT)	108	CI(OVC)	258										
12	64	58	18	17	10110	10	SC(SCT)	68	AC(OVC)	108										
13	35	51	12	15	10098	10	SC(SCT)	68	AS(OVC)	108										
14	29	54	11	13	10086	10	AS(OVC)	98												
15	12	54	17	15	10065	10	SC(MEN)	34	AS(OVC)	98										
16	21	73	28	22	10057	10	SC(OVC)	31												
17	27	81	28	24	10053	10	SF(MEN)	14	SC(OVC)	38								1		
18	31	93	16	17	10048	10	P(-X)		SF(MEN)	7	SC(OVC)	15						1		
19	11	94	10	17	10040	10	SF(MEN)	9	SC(OVC)	15								1		
20	18	92	13	15	10043	10	SF(OVC)	10												
21	28	98	28	22	10048	10	SF(MEN)	10	SC(OVC)	15				1				1		
22	32	88	28	22	10034	10	SF(OVC)	10						1						
23	32	88	28	24	10023	10	SF(OVC)	10						1						

SURFACE WEATHER OBSERVATION AT OTTAWA ON FEBRUARY 2, 1981

CST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES 0.01 kPa	TOTAL CLD AMT	CLOUDS TYPE	HT 30m	TYPE	HT 30m	TYPE	HT 30m	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	32	98	28	22	10017	10	SF(OVC)	12												
1	29	93	28	22	10005	10	SF(OVC)	12						1						
2	31	93	28	22	10001	10	SF(OVC)	11						1						
3	33	95	10	15	9987	10	SF(OVC)	10						1						
4	28	99	17	9	9980	10	SF(OVC)	10						1						
5	28	99	17	7	9978	10	SF(OVC)	8						1						
6	33	98	21	9	9978	10	SF(OVC)	8						1						
7	31	98	21	11	9961	10	SF(MEN)	8	SC(OVC)	15				1						
8	29	99	28	9	9961	10	SF(MEN)	8	SC(OVC)	15				1						
9	26	96	21	13	9959	10	SF(MEN)	9	ST(OVC)	11				1						
10	28	97	17	9	9952	10	SF(MEN)	8	ST(OVC)	12				1						
11	11	98	17	13	9942	10	SF(-MEN)	8	SC(OVC)	12				1						
12	9	99	21	13	9935	10	P(-X)	3	SC(X)	99				1						
13	9	99	23	11	9928	10	SF(MEN)	4						1				1		
14	10	97	24	17	9921	10	SF(SCT)	4	SC(OVC)	28				1				2		
15	15	78	24	20	9929	10	SF(-SCT)	11	SC(OVC)	38										
16	7	71	24	24	9939	10	SC(OVC)	21	SC(MEN)	21	AC(OVC)	98								
17	-10	91	24	30	9958	7	SC(-MEN)	21										1		
18	-17	78	23	33	9961	9	SC(MEN)	21										1		
19	-29	85	24	24	9971	9	SC(SCT)	34	SC(OVC)	55								1		
20	-41	88	29	31	9992	10	SC(OVC)	21												
21	-01	84	30	24	10014	10	SC(OVC)	21												
22	-01	67	26	22	10030	8	SC(MEN)	23										1		
23	-98	67	27	39	10041	8	SC(MEN)	24										1		

SURFACE WEATHER OBSERVATION AT OTTAWA ON FEBRUARY 3, 1981

CST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES 0.01 kPa	TOTAL CLD AMT	CLOUDS TYPE	HT 30m	TYPE	HT 30m	TYPE	HT 30m	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-108	75	29	28	10051	9	SC(MEN)	35												
1	-118	74	30	15	10056	7	SC(-MEN)	38										1		
2	-133	80	30	28	10070	10	PC (X)		SC(OVC)	38								1		
3	-164	71	30	28	10079	7	SC(-MEN)	35												
4	-178	78	30	22	10088	2	SC(SCT)	35												
5	-182	54	30	22	10102	1	SC(SCT)	35												
6	-192	55	29	22	10112	0														
7	-202	61	30	17	10124	0														
8	-206	68	29	19	10145	0														
9	-208	59	29	17	10141	0														
10	-199	56	30	17	10150	0														
11	-194	55	30	15	10152	0														
12	-186	59	30	13	10151	0														
13	-188	58	31	13	10148	0														
14	-178	54	32	15	10148	7	CI(-MEN)	228												
15	-164	58	29	13	10153	3	CU(SCT)	34												
16	-168	49	29	13	10158	3	CI(-SCT)	218	CI(-SCT)	218										
17	-164	58	28	13	10166	7	CB(-MEN)	218												
18	-170	52	26	6	10173	0	CB(-MEN)	218												
19	-175	55	0	0	10184	0														
20	-175	54	0	0	10179	0														
21	-168	51	20	4	10171	0														
22	-173	55	19	6	10170	0														
23	-179	57	28	6	10168	0														

SURFACE WEATHER OBSERVATION AT PETANANA ON FEBRUARY 1, 1981

EST	DRY BULB (0.1C)	RH (%)	WIND DIR (10*S)	WIND SPD (KM/H)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10TH)	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-137	66	9	7	10248	7	CI(-BKN)	250												
1	-134	86	33	6	10236	7	CI(-BKN)	250												
2	-119	86	15	7	10232	4	CI(-SCT)	250												
3	-123	95	13	9	10223	4	CI(-SCT)	250												
4	-128	95	13	9	10211	7	CI(BKN)	250												
5	-127	84	13	15	10193	5	ST(-SCT)	5												
6	-133	95	13	13	10176	7	ST(BKN)	5												
7	-99	84	13	13	10156	10	ST(OVC)	5												
8	-95	84	14	19	10142	10	AC(SCT)	80	CI(OVC)	220										
9	-88	75	15	17	10137	10	AC(BKN)	100	CI(OVC)	220										
10	-93	73	14	17	10111	10	AC(BKN)	100	CI(OVC)	220										
11	-82	64	14	19	10086	10	AC(SCT)	100	CI(OVC)	220										
12	-72	61	15	17	10062	10	AC(SCT)	100	CI(OVC)	220										
13	-59	58	13	15	10027	10	AC(BKN)	100	CI(OVC)	220										
14	-42	58	15	22	10015	10	AC(OVC)	100												
15	-40	84	13	13	10022	10	PC(-X)	4										1		
16	-38	89	15	19	10089	10	PC(-X)		SC(OVC)	25								2		
17	-28	86	14	13	10012	10	PC(-X)		SC(OVC)	25								1		1
18	-22	95	12	19	10004	10	SC(OVC)	30										1		
19	-16	95	13	19	10005	10	SC(OVC)	28										1		
20	-11	87	12	19	10008	10	SC(OVC)	25										1		
21	-8	89	13	13	99981	10	PC(-X)		SC(OVC)	25								1		
22	0	91	12	15	99931	10	PC(-X)		SC(OVC)	15								1		
23	5	89	13	13	99871	10	SC(OVC)	28					1					1		

SURFACE WEATHER OBSERVATION AT PETANANA ON FEBRUARY 2, 1981

EST	DRY BULB (0.1C)	RH (%)	WIND DIR (10*S)	WIND SPD (KM/H)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10TH)	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	6	88	14	15	99661	10	SC(OVC)	16										1		
1	4	78	14	11	99721	10	SC(BKN)	17	AC(OVC)	100								1		
2	6	89	14	11	99681	10	SC(OVC)	17										1		
3	5	89	14	13	99581	10	SC(OVC)	15										1		
4	6	87	13	13	99571	10	SC(BKN)	15	AC(OVC)	100								1		
5	5	89	14	11	99581	10	SC(OVC)	15										1		
6	5	98	13	11	99451	10	SC(SCT)	15	AC(OVC)	100								1		
7	7	91	14	9	99441	10	SP(SCT)	10	SC(OVC)	30			1					1		
8	2	71	25	6	99461	10	SP(SCT)	2	SC(OVC)	28			1					1		
9	0	92	26	6	99481	10	SP(SCT)	3	SC(SCT)	28								1		
10	5	80	26	7	99431	9	SP(SCT)	6	SC(BKN)	35	SC(OVC)	35						1		
11	4	85	34	11	99391	10	SC(OVC)	7												
12	-3	80	31	7	99321	10	SC(OVC)	11										1		
13	-2	81	0	0	99191	9	SC(BKN)	28										1	1	
14	-1	66	24	19	99171	10	SC(OVC)	28										1		
15	-10	75	23	19	99211	9	SC(BKN)	28												1
16	-66	78	30	33	99471	10	PC(-X)		SP(SCT)	10	SC(OVC)	28								1
17	-95	68	32	26	99651	7	SP(SCT)	10	SC(BKN)	25										1
18	-110	71	30	31	99851	6	SP(SCT)	10	SC(BKN)	25										1
19	-129	65	29	28	10008	10	SP(SCT)	10	SC(OVC)	30										
20	-154	68	30	28	10020	2	SC(SCT)	30	--											
21	-168	67	32	26	10038	10	SC(OVC)	45												
22	-178	67	31	19	10058	10	SC(OVC)	40												
23	-189	68	30	19	10056	2	SC(SCT)	40												

SURFACE WEATHER OBSERVATION AT PETANANA ON FEBRUARY 3, 1981

EST	DRY BULB (0.1C)	RH (%)	WIND DIR (10*S)	WIND SPD (KM/H)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10TH)	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-201	54	29	11	10068	1	SC(SCT)	40												
1	-212	57	30	15	10088	0														
2	-222	58	29	15	10098	0														
3	-232	59	29	13	10097	0														
4	-236	68	28	9	10105	0														
5	-250	61	27	7	10114	0														
6	-260	63	27	9	10129	0														
7	-285	64	25	7	10132	1	CI(-SCT)	250												
8	-293	66	29	7	10141	2	SC(SCT)	30	CI(-SCT)	250										
9	-253	65	27	6	10149	3	SC(SCT)	30	CI(-SCT)	250										
10	-233	58	31	13	10153	10	SC(SCT)	30	CB(-OVC)	250										
11	-229	56	27	17	10158	8	SC(SCT)	30	AC(SCT)	80	CS(-BKN)	250								1
12	-215	49	29	19	10158	10	SC(SCT)	30	CI(-OVC)	250										1
13	-204	47	32	11	10157	4	SC(SCT)	30	CI(-SCT)	250										
14	-189	44	27	15	10155	7	SC(SCT)	30	CB(-BKN)	250										
15	-181	42	30	11	10158	4	SC(SCT)	30	CI(-SCT)	250										
16	-183	44	4	7	10158	3	SC(SCT)	30	CI(-SCT)	250										
17	-187	46	4	4	10163	1	SP(SCT)	29	SC(SCT)	30										
18	-217	57	0	0	10160	1	SC(SCT)	30												
19	-239	65	18	6	10170	0														
20	-247	65	0	0	10184	1	SC(SCT)	30												
21	-259	68	0	0	10186	1	SC(SCT)	30												
22	-268	65	0	0	10183	2	SC(SCT)	30												
23	-255	61	0	0	10178	1	SC(SCT)	30												

SURFACE WEATHER OBSERVATION AT NORTH DAY ON FEBRUARY 1, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	-198	84	17	9	1	1	SC(SCT)	34												
1	-99	84	18	13	2	1	SC(SCT)	34												
2	-98	76	17	15	9	1	SC(SCT)	40												
3	-98	74	14	13	0	8	SC(SCT)	43	CI(-BKN)	250										
4	-188	72	14	19	5	10	SC(BKN)	38	CI(OVC)	250										
5	-86	63	13	20	4	10	SC(OVC)	43												
6	-83	62	13	22	5	10	SC(SCT)	44	CI(OVC)	250										
7	-82	64	12	24	9	10	SC(BKN)	43	CI(OVC)	230										
8	-80	64	12	30	7	10	SC(BKN)	40	AS(OVC)	100										
9	-79	65	14	26	6	10	SC(SCT)	40	AS(BKN)	100	AC(OVC)	150								
10	-66	68	15	30	8	10	SC(SCT)	38	AS(OVC)	100										
11	-56	58	15	19	5	10	SC(BKN)	38	AS(OVC)	90										
12	-46	88	19	28	6	10	PC	X)	2										21	
13	-48	91	18	26	9	10	PC	X)	3										21	
14	-48	92	19	24	9	10	PC	X)	4										21	
15	-33	93	19	24	9	10	PC	X)	4										21	
16	-25	94	17	13	9	10	PC	-X)		SF(OVC)	4								11	
17	-18	95	21	19	9	10	PC	X)	2										21	
18	-14	95	20	15	9	10	PC	X)	2										21	
19	-8	96	22	22	9	10	PC	X)	2										11	
20	-4	98	22	17	9	10	PC	X)											11	
21	-3	98	21	17	9	10	PC	X)											11	
22	-2	98	21	11	9	10	PC	X)	2										21	
23	-2	98	21	15	9	10	PC	X)	3										11	

SURFACE WEATHER OBSERVATION AT NORTH DAY ON FEBRUARY 2, 1981

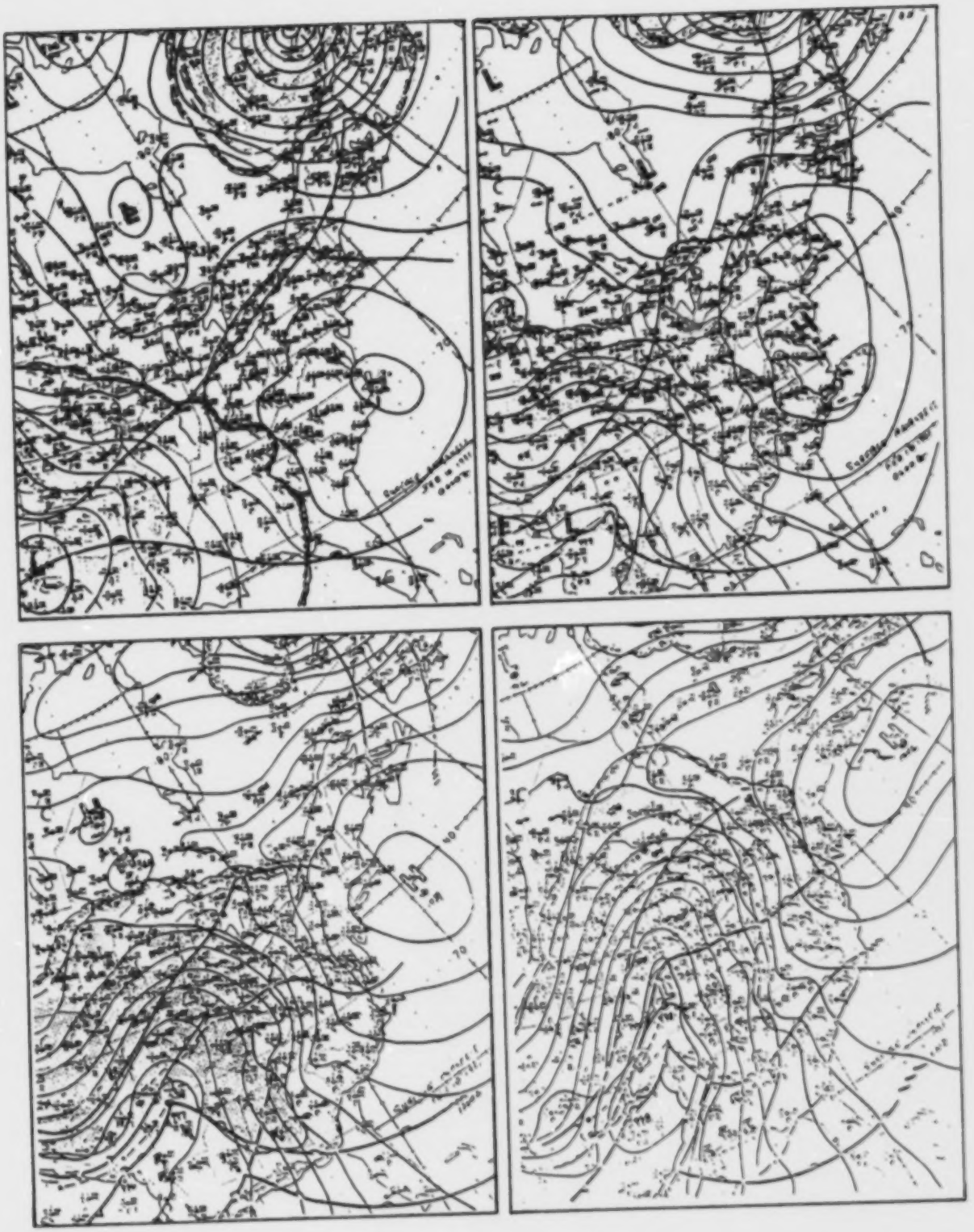
EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	2	98	21	13	9	10	SF(BKN)	1	SF(OVC)	4										
1	3	98	23	13	9	10	SF(OVC)	2												
2	-1	76	23	15	9	10	SF(SCT)	3	SF(OVC)	6										
3	-14	96	27	13	9	10	PC	-X)	SF(OVC)	2										
4	17	94	27	15	9	10	PC	-X)	SF(OVC)	5										
5	-28	96	27	7	9	10	PC	-X)	SF(OVC)	2										
6	26	96	25	9	9	10	SF(BKN)	3	SF(OVC)	7										
7	-38	95	21	22	9	10	SF(SCT)	3	SF(OVC)	5										
8	-118	87	11	22	9	10	SF(OVC)	7												
9	-133	87	11	20	9	10	SF(OVC)	9												
10	-155	87	11	20	9	10	SC(OVC)	10												
11	-164	86	11	26	9	10	SC(OVC)	14												
12	-169	84	11	24	9	10	PC	-X)	WC(OVC)	16										
13	-169	86	11	15	9	10	PC	-X)	SC(OVC)	16										
14	-175	87	35	15	9	10	PC	-X)	SC(BKN)	16	AC(OVC)	120								
15	-179	83	35	15	9	10	PC	-X)	SC(BKN)	16	AC(OVC)	120								
16	-181	83	35	15	9	10	PC	X)	10											
17	-192	84	33	13	8	10	PC	-X)	SC(BKN)	16	AC(OVC)	120								
18	-198	71	34	6	8	10	PC	-X)	SC(BKN)	16	AC(OVC)	120								
19	-203	71	33	7	8	10	PC	-X)	SC(BKN)	16	AC(OVC)	120								
20	-219	69	33	7	8	10	PC	-X)	SC(OVC)	9										
21	-230	67	34	11	9	10	PC	-X)	SC(OVC)	8										
22	-245	64	33	11	9	10	PC	-X)	SC(-BKN)	31										
23	-252	64	32	7	9	10	PC	-X)	SC(OVC)	24										

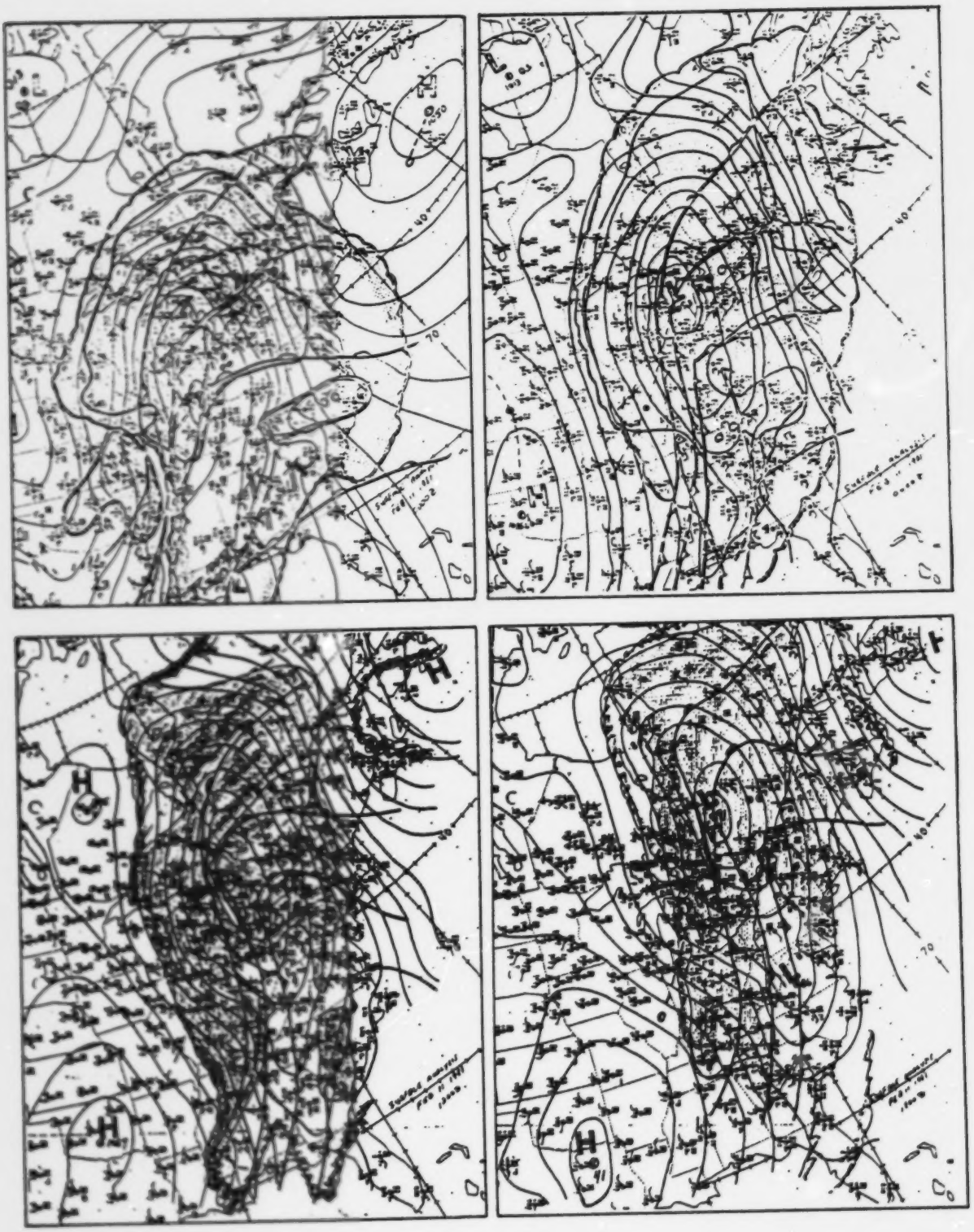
SURFACE WEATHER OBSERVATION AT NORTH DAY ON FEBRUARY 3, 1981

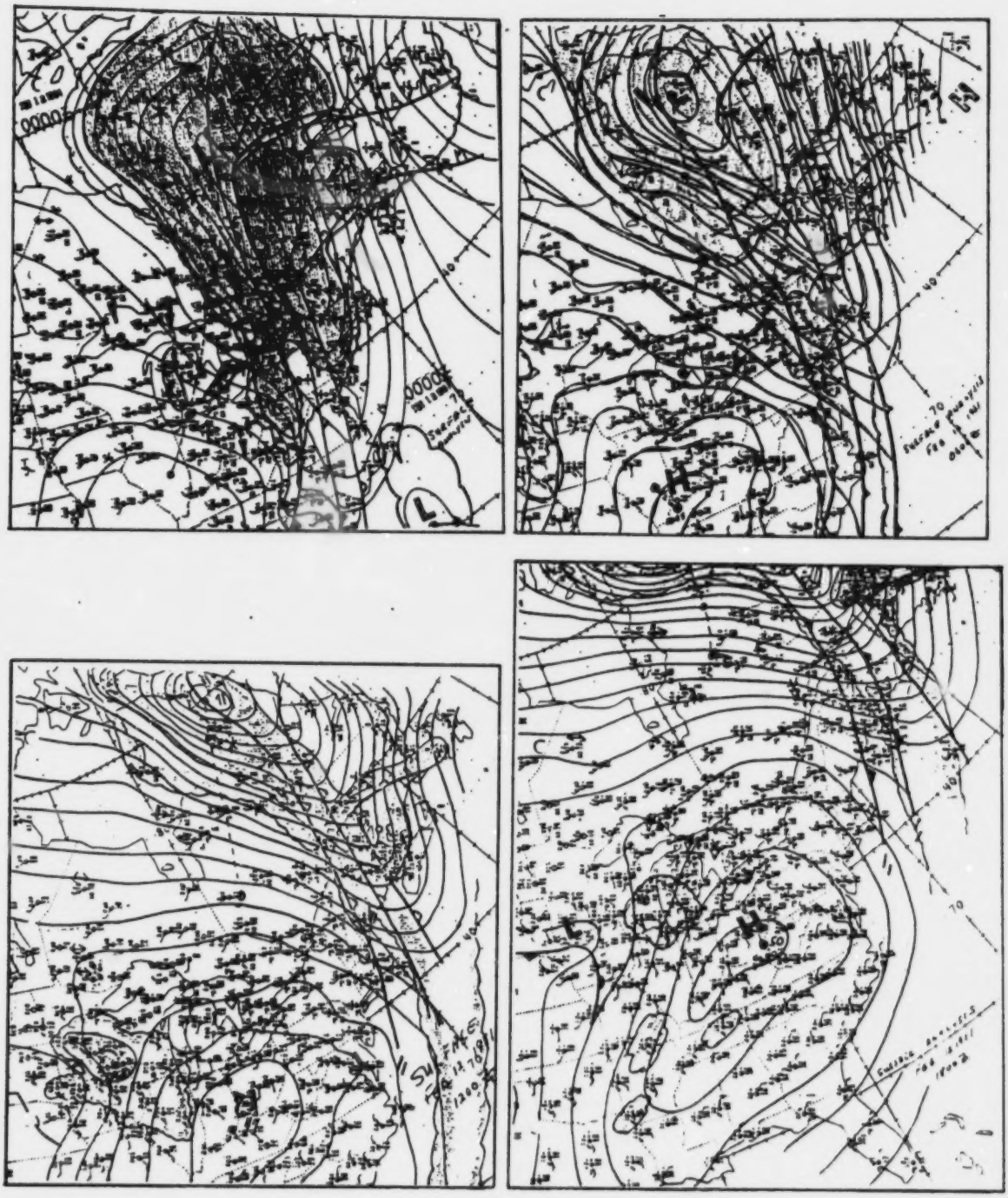
EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	-256	63	33	7	10	8	PC	-X)	SC(OVC)	24										
1	-259	66	32	7	10	9	SC(OVC)	22												
2	-263	66	29	6	10	9	SC(BKN)	28												
3	-276	68	30	4	10	9	SC(-SCT)	28												
4	-286	66	32	6	10	10	SC(-SCT)	34												
5	-298	66	32	6	10	10	SF(-SCT)	7	SC(-BKN)	38										
6	-297	67	32	4	10	10	SC(-SCT)	38												
7	-305	65	30	6	10	10	SC(-SCT)	38												
8	-306	63	31	7	10	10	SC(SCT)	38	CI(-SCT)	250										
9	-308	65	32	7	10	10	CI(-SCT)	250												
10	-279	64	28	7	10	10	CI(SCT)	250												
11	-269	63	23	15	10	10	CI(SCT)	250												
12	-270	59	25	15	10	10	CI(SCT)	250												
13	-256	57	28	17	10	10	CI(SCT)	250												
14	-238	59	24	15	10	10	CI(SCT)	250												
15	-233	60	23	15	10	10	CI(SCT)	250												
16	-228	63	26	6	10	10	CI(-SCT)	250												
17	-226	65	31	9	10	10	AC(SCT)	120	CI(-BKN)	250										
18	-228	68	30	4	10	9	AC(SCT)	120	CI(-BKN)	250										
19	-225	70	30	7	10	10	AC(SCT)	120	CI(-BKN)	250										
20	-228	72	29	7	10	10	PC	-X)	CI(OVC)	250										
21	-222	72	29	7	10	10	CI(-SCT)	250												
22	-216	73	25	7	10	10	PC	-X)	CI(-BKN)	250										
23	-221	70	25	7	10	10	CI(-SCT)	250												

APPENDIX B

SURFACE SYNOTPIC WEATHER MAPS AND OBSERVATIONAL DATA FOR PRECIPITATION EPISODE 2: FEBRUARY 10 TO 12, 1981







SURFACE WEATHER OBSERVATION AT WINDSOR ON FEBRUARY 10, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10**2 N/m2	KM/H	0.01 KPA	10THS		30M		30M		30M								
0	-86	83	15	4	1022	10	CI(-OVC)	250												
1	-88	81	15	4	1022	10	CB(-OVC)	250												
2	-87	71	15	9	1022	10	CB(OVC)	250												
3	-81	72	11	9	1022	10	CB(OVC)	250												
4	-68	77	9	9	1021	10	AB(SCT)	150	CB(OVC)	250										
5	-47	78	10	13	1021	10	SC(SCT)	30	AB(OVC)	150										
6	-37	88	13	15	1021	10	AC(BKN)	80	AB(OVC)	150								1		
7	-32	87	12	19	1019	10	PL	-X										1		
8	-28	75	11	17	1018	7	PL	-X										1		
9	-28	92	10	19	1018	5	PL	-X										1		
10	-16	92	13	20	1018	5	PL	-X										3		
11	-14	92	12	33	1018	9	PL	-X										3		
12	-18	73	13	31	1018	10	PL	-X										3		
13	-14	96	14	29	1018	9	PL	-X										2		
14	2	96	15	28	1018	8	PL	-X										2		
15	5	95	14	29	1018	8	PL	-X										2		
16	5	95	14	28	1018	10	PL	-X										1		
17	16	93	15	24	1018	10	NS(OVC)	20					L							
18	17	92	15	24	1018	10	NS(OVC)	20					L							
19	19	94	15	26	9999	10	SF(SCT)	8	NS(OVC)	12			L							
20	24	95	15	30	9985	10	SF(SCT)	8	NS(OVC)	12			L							
21	35	95	16	26	9975	10	SF(BKN)	8	NS(OVC)	15			L		L					
22	54	92	28	44	9978	10	SF(BKN)	8	NS(OVC)	14			L		L					
23	41	97	28	26	9972	10	NS(OVC)	9					L							

SURFACE WEATHER OBSERVATION AT WINDSOR ON FEBRUARY 11, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10**2 N/m2	KM/H	0.01 KPA	10THS		30M		30M		30M								
0	51	96	10	33	9964	10	SF(SCT)	5	NS(OVC)	22			L							
1	48	97	10	31	9958	10	SF(BKN)	3	NS(OVC)	22			L							
2	42	97	20	17	9947	10	PL	-X					L							
3	38	97	24	17	9946	10	PL	-X					L							
4	34	99	22	9	9936	10	SF(OVC)	1					L							
5	32	98	26	22	9942	10	SF(SCT)	5	SF(BKN)	10	SC(OVC)	25	L							
6	11	95	20	17	9956	10	SF(OVC)	10										1		
7	-11	86	28	35	9985	10	SF(OVC)	10										1		
8	-45	77	28	37	10013	10	SC(BKN)	13	SC(OVC)	30								1		
9	-53	76	29	33	10029	10	SC(BKN)	15	SC(OVC)	40										
10	-67	74	30	37	10035	10	SC(BKN)	10	SC(OVC)	25								1		
11	-78	67	30	33	10048	10	SC(SCT)	10	AS(OVC)	80										
12	-67	68	29	35	10038	10	SC(BKN)	25	ST(OVC)	50								1		
13	-63	75	29	31	10039	10	PL	-X	SC(OVC)	20								1		
14	-91	67	29	41	10106	10	PL	-X	SC(OVC)	20								1		
15	-93	64	29	41	10130	10	SC(BKN)	20	ST(OVC)	40								1		
16	-96	68	28	44	10156	10	SC(SCT)	20	ST(OVC)	40										
17	-96	68	28	37	10174	10	SC(BKN)	20	AS(OVC)	90										
18	-101	68	28	37	10178	8	SC(BKN)	20	AS(BKN)	90										
19	-108	59	28	37	10219	7	SC(BKN)	20	CS(BKN)	200								1		
20	-122	71	28	31	10242	4	SF(SCT)	20												
21	-131	73	29	35	10263	10	PL	-X	SC(OVC)	22										1
22	-139	45	27	35	10284	4	SF(SCT)	22												
23	-144	58	27	28	10303	4	SF(SCT)	20												

SURFACE WEATHER OBSERVATION AT WINDSOR ON FEBRUARY 12, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
	0.1C	%	10**2 N/m2	KM/H	0.01 KPA	10THS		30M		30M		30M								
0	-150	69	24	24	10329	10	PL	-X	SC(OVC)	20										1
1	-178	78	25	38	10388	3	CU(SCT)	20												1
2	-178	64	25	26	10454	3	CU(SCT)	20												1
3	-181	64	24	19	10366	3	CU(SCT)	20												1
4	-189	66	25	19	10377	3	CU(SCT)	20												1
5	-182	66	25	20	10389	3	SC(SCT)	30												1
6	-188	64	24	19	10406	5	SC(SCT)	20												1
7	-183	64	24	19	10420	9														1
8	-186	66	24	19	10433	9														1
9	-177	65	24	15	10436	9														1
10	-164	63	23	19	10443	1	CI(SCT)	200												
11	-145	62	23	19	10458	1	CI(-SCT)	200												
12	-133	61	21	20	10451	1	AC(SCT)	80												
13	-126	68	23	20	10464	1	CU(SCT)	25	AC(SCT)	100										
14	-112	53	23	22	10458	4	CU(SCT)	25	CI(-SCT)	220										
15	-112	55	21	22	10448	10	CU(SCT)	25	CI(OVC)	200										
16	-108	56	19	24	10449	5	CU(SCT)	25	CI(SCT)	200										
17	-108	56	20	20	10444	9	CU(SCT)	25	AC(SCT)	100	CI(BKN)	200								
18	-108	56	20	22	10446	8	AC(SCT)	150	CI(-BKN)	200										
19	-105	58	19	17	10443	9	AC(SCT)	150	CI(-BKN)	200										
20	-103	63	19	19	10439	10	AC(SCT)	150	CI(BKN)	200										
21	-108	63	19	26	10444	10	AC(BKN)	120	CI(OVC)	200										
22	-102	69	19	24	10440	2	AC(SCT)	120												
23	-110	69	19	19	10437	1	AC(SCT)	120												

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 10, 1981

EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
	DEG C	DEG C						300 M		300 M		300 M								
0	10.1	3.1	310	5	1014.3	10														
1	9.6	3.1	310	5	1014.3	10														
2	9.6	3.1	310	5	1014.3	10														
3	9.6	3.1	310	5	1014.3	10														
4	9.6	3.1	310	5	1014.3	10														
5	9.6	3.1	310	5	1014.3	10														
6	9.6	3.1	310	5	1014.3	10														
7	9.6	3.1	310	5	1014.3	10														
8	9.6	3.1	310	5	1014.3	10														
9	9.6	3.1	310	5	1014.3	10														
10	9.6	3.1	310	5	1014.3	10														
11	9.6	3.1	310	5	1014.3	10														
12	9.6	3.1	310	5	1014.3	10														
13	9.6	3.1	310	5	1014.3	10														
14	9.6	3.1	310	5	1014.3	10														
15	9.6	3.1	310	5	1014.3	10														
16	9.6	3.1	310	5	1014.3	10														
17	9.6	3.1	310	5	1014.3	10														
18	9.6	3.1	310	5	1014.3	10														
19	9.6	3.1	310	5	1014.3	10														
20	9.6	3.1	310	5	1014.3	10														
21	9.6	3.1	310	5	1014.3	10														
22	9.6	3.1	310	5	1014.3	10														
23	9.6	3.1	310	5	1014.3	10														

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 11, 1981

EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
	DEG C	DEG C						300 M		300 M		300 M								
0	10.1	3.1	310	5	1014.3	10														
1	9.6	3.1	310	5	1014.3	10														
2	9.6	3.1	310	5	1014.3	10														
3	9.6	3.1	310	5	1014.3	10														
4	9.6	3.1	310	5	1014.3	10														
5	9.6	3.1	310	5	1014.3	10														
6	9.6	3.1	310	5	1014.3	10														
7	9.6	3.1	310	5	1014.3	10														
8	9.6	3.1	310	5	1014.3	10														
9	9.6	3.1	310	5	1014.3	10														
10	9.6	3.1	310	5	1014.3	10														
11	9.6	3.1	310	5	1014.3	10														
12	9.6	3.1	310	5	1014.3	10														
13	9.6	3.1	310	5	1014.3	10														
14	9.6	3.1	310	5	1014.3	10														
15	9.6	3.1	310	5	1014.3	10														
16	9.6	3.1	310	5	1014.3	10														
17	9.6	3.1	310	5	1014.3	10														
18	9.6	3.1	310	5	1014.3	10														
19	9.6	3.1	310	5	1014.3	10														
20	9.6	3.1	310	5	1014.3	10														
21	9.6	3.1	310	5	1014.3	10														
22	9.6	3.1	310	5	1014.3	10														
23	9.6	3.1	310	5	1014.3	10														

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 12, 1981

EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
	DEG C	DEG C						300 M		300 M		300 M								
0	10.1	3.1	310	5	1014.3	10														
1	9.6	3.1	310	5	1014.3	10														
2	9.6	3.1	310	5	1014.3	10														
3	9.6	3.1	310	5	1014.3	10														
4	9.6	3.1	310	5	1014.3	10														
5	9.6	3.1	310	5	1014.3	10														
6	9.6	3.1	310	5	1014.3	10														
7	9.6	3.1	310	5	1014.3	10														
8	9.6	3.1	310	5	1014.3	10														
9	9.6	3.1	310	5	1014.3	10														
10	9.6	3.1	310	5	1014.3	10														
11	9.6	3.1	310	5	1014.3	10														
12	9.6	3.1	310	5	1014.3	10														
13	9.6	3.1	310	5	1014.3	10														
14	9.6	3.1	310	5	1014.3	10														
15	9.6	3.1	310	5	1014.3	10														
16	9.6	3.1	310	5	1014.3	10														
17	9.6	3.1	310	5	1014.3	10														
18	9.6	3.1	310	5	1014.3	10														
19	9.6	3.1	310	5	1014.3	10														
20	9.6	3.1	310	5	1014.3	10														
21	9.6	3.1	310	5	1014.3	10														
22	9.6	3.1	310	5	1014.3	10														
23	9.6	3.1	310	5	1014.3	10														

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 10, 1981

EST	DRY BULB (0.1C)	RH %	WIND DIR (10's deg)	WIND SPD (km/h)	SEA LVL PRES (0.01 kPa)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30m)	TYPE	HT (30m)	TYPE	HT (30m)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-98	89	17	7	10237	8														
1	-85	90	17	7	10237	8														
2	-88	85	18	9	10240	8														
3	-104	86	9	8	10249	8														
4	-110	93	8	8	10256	5	CI(-SCT)	240												
5	-98	86	8	8	10257	9	AC(BKN)	100												
6	-98	86	8	8	10255	10	AC(OVC)	100												
7	-84	89	8	8	10253	10	AC(OVC)	110												
8	-92	96	8	8	10252	10	AC(OVC)	110												
9	-36	79	12	13	10240	10	AC(OVC)	100												
10	-33	83	10	29	10227	10	AC(OVC)	100												
11	-24	81	6	29	10226	10	SC(SCT)	25	AC(OVC)	90										
12	-12	77	10	22	10205	10	SC(SCT)	25	AC(OVC)	90										
13	-7	74	11	24	10188	10	ST(OVC)	16										1		
14	-14	94	12	33	10168	10	PC	-X)	ST(OVC)	16								1		
15	-9	96	12	30	10155	10	PC	X)	12									1		
16	-1	100	14	37	10137	10	PC	X)	3									2		
17	0	100	14	38	10135	10	PC	X)	1									3		
18	0	100	14	33	10126	10	PC	X)	3									2		
19	0	100	12	30	10114	10	PC	X)	2									3		
20	4	100	13	24	10089	10	PC	X)	12									1		
21	5	100	10	24	10071	10	PC	X)	16									1		
22	12	95	13	22	10043	10	PC	-X)			SF(SCT)	11	ST(OVC)	15	1					
23	25	100	12	22	10030	10	PC	-X)			SF(SCT)	10	ST(OVC)	22	1					

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 11, 1981

EST	DRY BULB (0.1C)	RH %	WIND DIR (10's deg)	WIND SPD (km/h)	SEA LVL PRES (0.01 kPa)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30m)	TYPE	HT (30m)	TYPE	HT (30m)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	43	93	17	17	10823	10	SF(SCT)	10	SC(OVC)	16			1							
1	58	95	17	20	10811	10	SF(SCT)	10	SC(OVC)	15			1							
2	57	98	17	30	9973	10	SF(SCT)	16	SC(OVC)	24			1							
3	57	98	16	19	9978	10	SC(OVC)	24					1							
4	60	92	17	26	9969	10	SC(OVC)	24					1							
5	67	93	16	30	9961	10	SC(OVC)	17					1							
6	65	97	17	30	9958	10	SF(SCT)	16	MS(OVC)	26			1							
7	69	96	18	26	9946	10	SF(SCT)	10	MS(OVC)	15			1							
8	65	95	18	19	9946	10	SF(OVC)	14					1							
9	78	95	19	26	9948	10	SF(OVC)	9						1						
10	65	92	21	28	9967	10	SF(BKN)	9	SC(BKN)	10	AC(OVC)	80								
11	48	91	27	24	9981	9	SF(SCT)	8	SC(BKN)	16										
12	-15	88	28	20	10061	10	SC(SCT)	14	SC(OVC)	40										
13	-34	76	30	26	10115	10	SC(SCT)	14	SC(BKN)	40	AC(OVC)	80								
14	-34	88	27	30	10141	10	PC	-X)	CF(SCT)	12	SC(OVC)	22								1
15	-71	84	27	35	10169	10	PC	-X)	CF(SCT)	12	SC(OVC)	28								1
16	81	88	27	31	10185	10	PC	X)	SC(OVC)	18										1
17	-27	83	28	43	10101	10	CF(SCT)	18	SC(OVC)	19										1
18	-44	75	27	37	10125	10	CF(SCT)	12	SC(SCT)	22	AC(OVC)	80								
19	-46	77	28	35	10148	9	CU(SCT)	20	AC(BKN)	70										
20	-91	62	29	41	10159	10	SC(BKN)	25	AC(OVC)	70										1
21	-103	83	27	46	10177	8	SC(BKN)	25												
22	-113	85	28	37	10198	4	CF(SCT)	23	SC(SCT)	25										
23	-123	83	28	37	10221	1	CF(SLT)	20	SC(SCT)	30										

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 12, 1981

EST	DRY BULB (0.1C)	RH %	WIND DIR (10's deg)	WIND SPD (km/h)	SEA LVL PRES (0.01 kPa)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30m)	TYPE	HT (30m)	TYPE	HT (30m)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-133	76	27	26	10246	1	CF(SCT)	25												
1	-139	72	28	39	10247	2	SC(SCT)	25												
2	-151	88	29	35	10237	0														
3	-156	79	29	33	10247	0														
4	-163	75	28	38	10233	0														
5	-167	78	28	33	10250	0														
6	-171	77	28	24	10266	0														
7	-173	78	28	29	10281	0														
8	-174	78	26	15	10285	11	CU(SCT)	23												
9	-163	63	29	28	10219	11	CU(SCT)	28												
10	-153	62	29	31	10208	6	CU(SCT)	29	CI(-BKN)	250										
11	-149	63	28	35	10203	6	CU(SCT)	24	CI(-SCT)	250										
12	-139	65	25	31	10207	7	CU(SCT)	28	AC(SCT)	120	CI(-BKN)	250								
13	-135	57	28	30	10208	9	CU(SCT)	28	CI(-BKN)	250										
14	-130	58	27	22	10204	7	CU(SCT)	25	CI(-BKN)	250										
15	-123	62	26	26	10200	5	CU(SCT)	25												
16	-120	76	25	29	10209	4	CU(SCT)	25	CI(-SCT)	260										
17	-121	80	25	19	10254	4	CU(SCT)	25	CI(-SCT)	260										
18	-120	86	26	11	10254	3	CU(SCT)	24	AC(SCT)	100	CI(-SCT)	250								
19	-120	77	25	6	10258	3	AC(SCT)	100	CI(-SCT)	250										
20	-124	81	25	11	10258	2	SC(SCT)	25	CI(-SCT)	250										
21	-125	85	28	11	10246	0														
22	-125	85	28	11	10256	0														
23	-125	86	28	13	10256	6	AC(-BKN)	80												

SURFACE WEATHER OBSERVATION AT RENTON ON FEBRUARY 10, 1981

EST	DRY BULB (10.1C)	RH (%)	WIND DIR (10's)	WIND SPD (KM/h)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30M)	TYPE	HT (30M)	TYPE	HT (30M)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
0	-66	81	23	6	10238	5	SC(SCT)	10												
1	-65	73	22	6	10258	7	SC(BKN)	50												L
2	-81	66	26	17	10254	2	SC(SCT)	50												
3	-70	73	26	9	10260	8														
4	-120	88	9	8	10261	8														
5	-125	79	8	8	10272	4	AC(SCT)	120												
6	-117	88	7	6	10279	10	SC(BKN)	25	AC(OVC)	120										
7	-108	83	6	6	10277	10	SC(SCT)	13	SC(BKN)	28	AC(OVC)	120								
8	-98	88	9	7	10283	10	SC(SCT)	28	AC(OVC)	120										
9	-62	88	8	9	10273	10	AC(OVC)	120												
10	-39	77	8	9	10268	10	AS(OVC)	120												
11	-16	84	12	17	10264	10	AC(OVC)	110												
12	-10	76	10	17	10258	10	SC(SCT)	30	AS(OVC)	100										
13	0	78	13	22	10234	10	SC(BKN)	30	AC(OVC)	90										
14	1	63	12	28	10219	10	ST(SCT)	14	SC(BKN)	30	AC(OVC)	70								
15	15	64	15	39	10213	10	SF(SCT)	9	SC(BKN)	14	SC(OVC)	30								L
16	13	78	16	33	10205	10	FG(-X)		SC(OVC)	14										L
17	-2	100	16	26	10194	10	FG(X)	4										2		L
18	0	98	14	28	10192	10	FG(X)	5												L
19	2	96	12	17	10182	10	FG(X)	6										1		
20	2	100	14	24	10164	10	FG(X)	9										1		
21	9	97	13	28	10129	10	SF(SCT)	6	SF(BKN)	14	NS(OVC)	22								
22	23	92	14	29	10097	10	SF(SCT)	6	NS(OVC)	23			L							
23	35	88	15	37	10083	10	NS(OVC)	25					L							

SURFACE WEATHER OBSERVATION AT RENTON ON FEBRUARY 11, 1981

EST	DRY BULB (10.1C)	RH (%)	WIND DIR (10's)	WIND SPD (KM/h)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30M)	TYPE	HT (30M)	TYPE	HT (30M)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
0	30	93	16	4	10264	10	SF(SCT)	7	NS(OVC)	25			L							
1	42	98	16	6	10255	10	SF(SCT)	7	NS(BKN)	25	NS(OVC)	35	L							
2	40	96	15	3	10258	10	SF(SCT)	5	NS(SCT)	25	NS(OVC)	40	L							
3	51	94	15	3	10232	10	SF(SCT)	5	NS(BKN)	30	NS(OVC)	45	L							
4	44	87	15	4	10212	10	NS(BKN)	30	NS(OVC)	45			L							
5	42	93	14	6	10204	10	SF(SCT)	7	NS(SCT)	30	NS(OVC)	45	L							
6	45	92	14	4	9992	10	SF(SCT)	7	SC(SCT)	20	NS(OVC)	40	L							
7	45	92	14	4	9984	10	NS(OVC)	40					L							
8	48	93	16	3	9970	10	SF(SCT)	5	SC(BKN)	30	AC(OVC)	40	L							
9	73	91	15	2	9972	10	SF(SCT)	5	SC(BKN)	30	AC(OVC)	80								
10	79	38	15	2	9972	10	SC(BKN)	30	SC(OVC)	40										
11	84	89	16	2	9975	10	SC(BKN)	25	SC(OVC)	40										
12	69	88	22	19	9984	10	SF(SCT)	6	SC(BKN)	12	SC(OVC)	10		L						
13	49	95	24	24	9983	10	SF(BKN)	5	SC(OVC)	13					L					
14	38	94	23	28	9988	10	FG(-X)		SF(BKN)	4	SC(OVC)	10			L					
15	14	94	23	28	9998	10	FG(-X)		SF(OVC)	4					L					
16	-12	99	20	41	10015	10	FG(X)	5							L			2		
17	-48	88	29	44	10046	10	FG(X)	8												
18	54	83	29	37	10071	10	FG(-X)		SC(OVC)	20								1		
19	62	77	26	44	10098	10	FG(X)	15										1		
20	74	75	26	44	10123	10	FG(X)		SF(SCT)	10	SC(OVC)	20						1		
21	-01	70	26	37	10149	10	FG(X)	10										1		
22	62	82	29	30	10172	10	FG(X)	15										1		
23	-98	78	28	37	10188	91	FG(-X)		SF(SCT)	10	SC(BKN)	25						1		

SURFACE WEATHER OBSERVATION AT RENTON ON FEBRUARY 12, 1981

EST	DRY BULB (10.1C)	RH (%)	WIND DIR (10's)	WIND SPD (KM/h)	SEA LVL PRES (0.01 KPA)	TOTAL CLD AMT (10ths)	CLOUDS TYPE	HT (30M)	TYPE	HT (30M)	TYPE	HT (30M)	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
0	-90	78	29	28	10287	7	SC(BKN)	25												
1	-113	76	28	28	10277	5	SC(SCT)	25												
2	-134	83	28	22	10260	2	SC(SCT)	25												
3	-140	76	28	28	10265	1	SC(SCT)	25												
4	-144	74	27	24	10292	1	SC(SCT)	25												
5	-153	77	28	26	10316	2	SC(SCT)	25												
6	-154	81	29	15	10334	6	SC(BKN)	25												L
7	-154	70	28	26	10344	3	SC(SCT)	22												L
8	-156	83	28	24	10384	2	SC(SCT)	22												
9	-151	83	28	38	10402	1	SC(SCT)	22												
10	-146	84	29	24	10409	1	SC(SCT)	23												
11	-137	82	28	28	10422	2	SC(SCT)	23												
12	-136	79	38	17	10423	2	SC(SCT)	23												
13	-126	86	29	17	10427	6	SC(SCT)	23	AC(-BKN)	100										
14	-122	87	28	22	10445	5	SC(SCT)	48	CI(SCT)	250										
15	-123	83	23	17	10438	6	SC(SCT)	48	AS(BKN)	120										
16	-128	88	27	26	10449	3	CU(SCT)	18												
17	-122	81	28	32	10458	2	SC(SCT)	38												
18	-133	63	28	17	10454	1	SC(SCT)	38												
19	-135	68	29	15	10468	1	SC(SCT)	38												
20	-135	68	29	13	10464	2	CI(-SCT)	250												
21	-136	64	28	9	10469	3	SC(SCT)	38	CI(-SCT)	250										
22	-142	67	34	7	10468	8														
23	-140	78	8	8	10467	3	SC(SCT)	38	CI(-SCT)	250										

SURFACE WEATHER OBSERVATION AT OTTAWA ON FEBRUARY 10, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES 0.01 EPA	TOTAL CLD AMT 10THS	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CM
	0.1C	%	10*DIR	KM/H																
0	-188	78	19	9	10233	3	SC(SCT)	45												
1	-191	73	20	7	10241	8														
2	-187	82	20	11	10256	8														
3	-186	87	21	9	10259	8														
4	-195	86	21	9	10262	8														
5	-197	87	19	9	10272	8														
6	-111	91	17	9	10284	8														
7	-111	93	16	7	10279	3	AC(-SCT)	90												
8	-98	94	17	15	10328	10	AC(SCT)	90	CI(-OVC)	210										
9	-84	91	14	9	10336	10	SC(OVC)	21												
10	-58	83	13	9	10298	10	SC(OVC)	21												
11	-77	87	6	13	10301	10	CC(OVC)	43												
12	-58	88	8	15	10277	10	AS(OVC)	70												
13	-46	75	10	15	10301	10	SC(BKN)	45	AS(OVC)	70										
14	-36	71	7	26	10267	10	SC(SCT)	34	AS(OVC)	70								1		
15	-32	72	9	24	10259	10	AS(OVC)	70												
16	-20	73	12	24	10257	10	PC -X)		SC(OVC)	22								1		
17	-28	96	10	22	10241	10	PC X)	9										1		
18	-16	97	13	22	10222	10	PC X)	6										1		
19	-17	99	9	13	10228	10	PC X)	5										2		
20	-12	99	9	17	10214	10	PC X)	6										1		
21	-10	98	10	22	10195	10	PC X)	6										1		
22	-5	99	11	28	10164	10	PC X)	5										2		
23	10	100	10	24	10139	10	SN(-BKN)	5	HO(OVC)	32			1					1		

SURFACE WEATHER OBSERVATION AT OTTAWA ON FEBRUARY 11, 1981

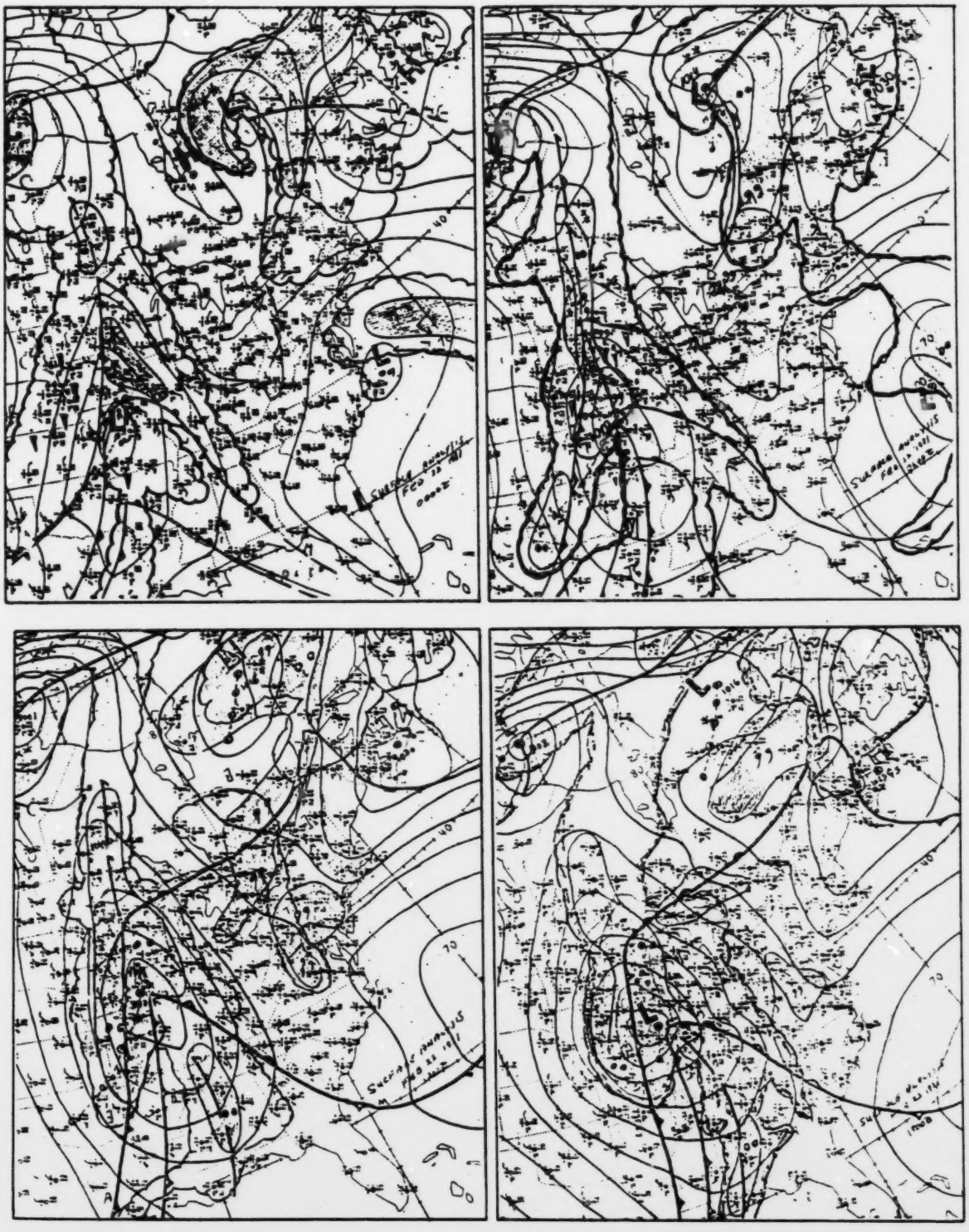
EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES 0.01 EPA	TOTAL CLD AMT 10THS	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CM
	0.1C	%	10*DIR	KM/H																
0	9	99	9	17	10121	10	SF(SCT)	10	HO(OVC)	29			1							
1	14	98	6	9	10111	10	SF(SCT)	10	HO(OVC)	25			1							
2	34	92	12	6	10102	10	HO(OVC)	28					1							
3	26	89	10	22	10088	10	HO(OVC)	22					1							
4	40	91	15	22	10067	10	HO(OVC)	22					1							
5	51	93	14	15	10054	10	HO(OVC)	38					1							
6	47	94	13	9	10043	10	HO(OVC)	38					1							
7	57	94	15	19	10038	10	SC(BKN)	42	AC(OVC)	70			1							
8	64	95	16	19	10022	10	SC(BKN)	38	AC(OVC)	70			1							
9	73	96	16	15	10011	10	SC(BKN)	38	AC(OVC)	70			1							
10	69	99	17	13	10001	10	SC(OVC)	49					2							
11	82	99	16	17	99981	10	SC(BKN)	10	AC(OVC)	70			1							
12	84	100	17	17	99951	10	SF(SCT)	7	SC(BKN)	15	SC(OVC)	40	1							
13	90	98	18	17	99731	10	SF(SCT)	7	SC(OVC)	45				1	1					
14	85	100	18	17	99641	10	SF(SCT)	8	SC(OVC)	45				1	1					
15	83	100	21	17	99641	10	FC -X)		SF(BKN)	2	SC(OVC)	10		1	1					
16	53	100	20	7	99681	10	SF(SCT)	9	SC(OVC)	30				1	1					
17	58	100	20	9	99781	10	SF(SCT)	7	SC(OVC)	35				1	1					
18	36	100	24	24	99911	10	SF(BKN)	7	SC(OVC)	355				1	1					
19	12	96	23	31	100280	10	PC -X)		SF(OVC)	7								1		
20	-20	100	24	28	100560	10	PC X)	7										1		
21	-48	95	24	33	100730	10	PC X)	7										1		
22	-61	95	25	30	101020	10	PC X)	7										1		
23	-78	94	25	30	101280	10	PC X)	7										1		

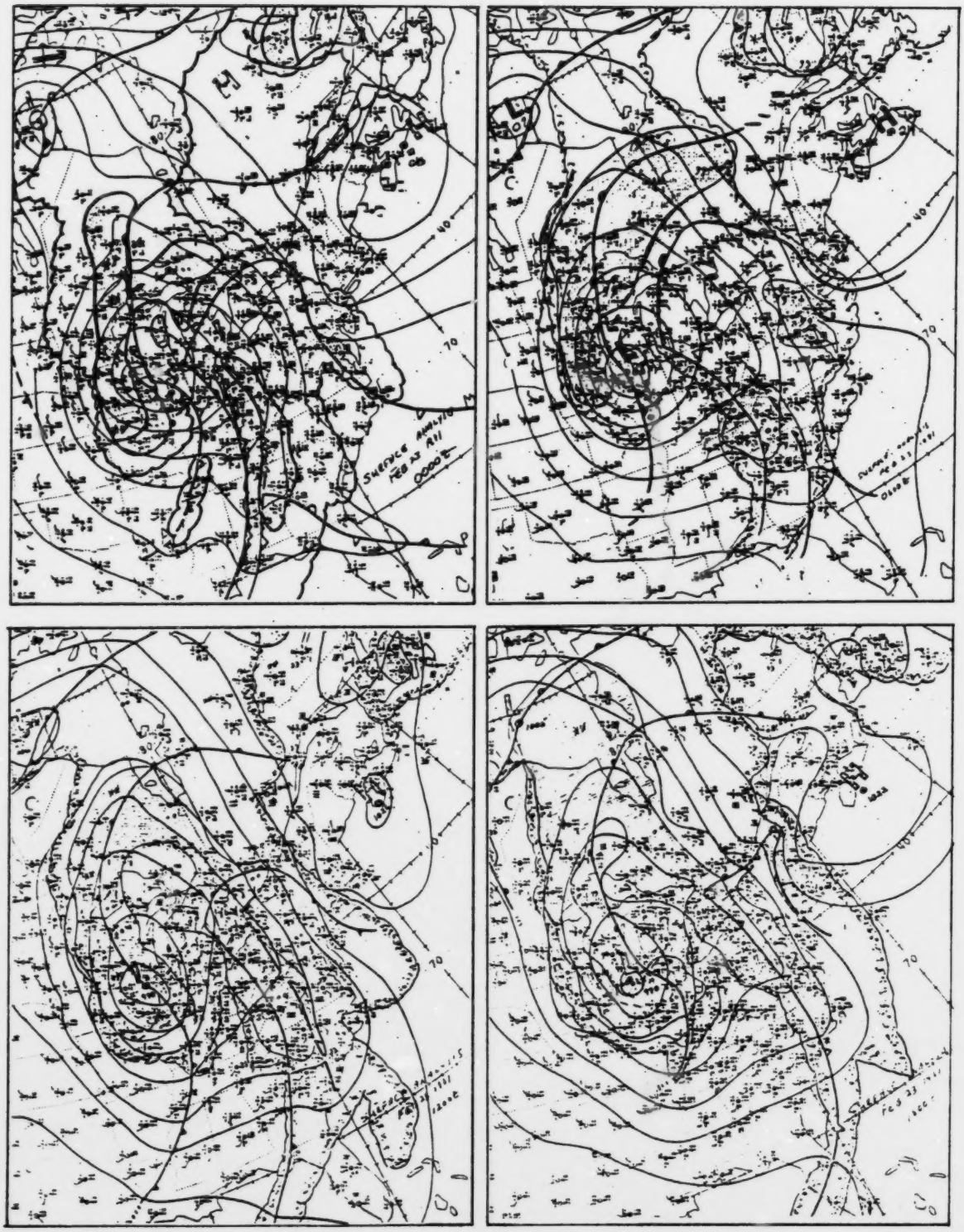
SURFACE WEATHER OBSERVATION AT OTTAWA ON FEBRUARY 12, 1981

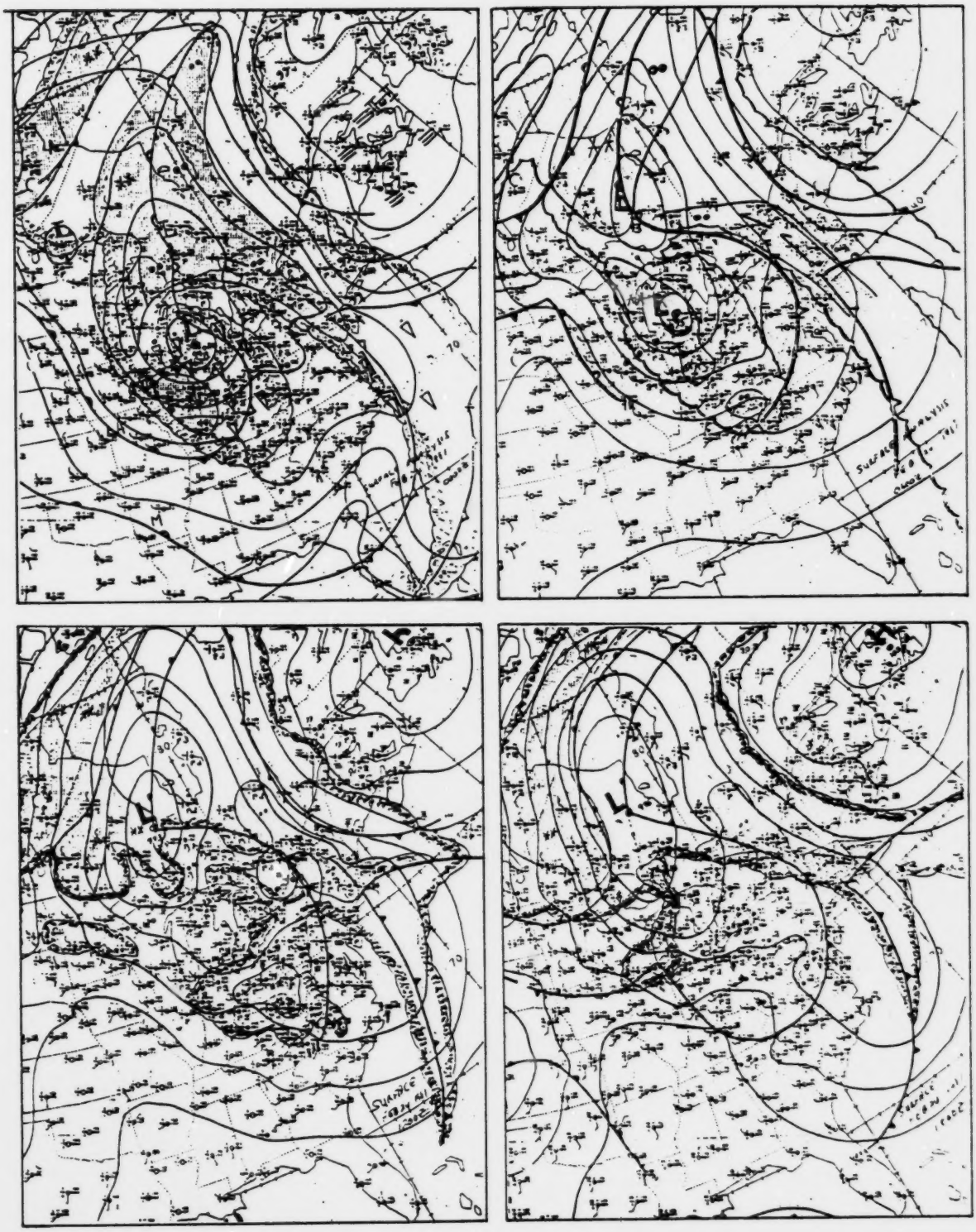
EST	DRY BULB	RH	WIND DIR	WIND SPD	SCA LVL PRES 0.01 EPA	TOTAL CLD AMT 10THS	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CM
	0.1C	%	10*DIR	KM/H																
0	-183	93	29	30	101330	10	PC X)	3										2		
1	-128	90	29	33	101270	10	PC X)	15										1		
2	-144	86	30	28	101260	4	PC -X)													
3	-154	83	31	28	101280	4	PC -X)													
4	-159	78	31	28	101240	1	SC(SCT)	40												
5	-164	83	28	26	101270	1	SC(SCT)	40												
6	-165	78	29	22	101270	2	HC(SCT)	30												
7	-178	81	29	26	101320	6	SN(-BKN)	8												
8	-182	84	28	22	101340	3	SF(-SCT)	10												
9	-177	91	28	20	101360	2	CF(SCT)	12												
10	-175	93	27	26	101380	1	CF(SCT)	10												
11	-169	93	28	19	101400	1	CF(SCT)	20												
12	-157	93	29	22	101400	1	CF(SCT)	20												
13	-149	91	28	20	101400	1	CF(SCT)	20												
14	-148	90	28	19	101410	1	CH(SCT)	30												
15	-137	90	30	11	101420	1	CF(SCT)	30												
16	-135	88	26	11	101420	4	HC(SCT)	25	CI(-SCT)	260										
17	-139	94	25	6	101430	7	CF(-SCT)	20	CC(-BKN)	30										
18	-141	84	0	0	101440	6	SC(-BKN)	10												
19	-144	89	16	4	101449	4	SC(-SCT)	20												
20	-147	86	25	9	101454	0														
21	-150	85	21	9	101443	0														
22	-153	86	23	9	101463	0														
23	-154	85	20	9	101467	0														

APPENDIX C

SURFACE SYNOPTIC WEATHER MAPS AND OBSERVATIONAL DATA FOR PRECIPITATION EPISODE 3: FEBRUARY 22 TO 24, 1981







SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 23, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100M	TYPE	HT 100M	TYPE	HT 100M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
	(DEG C)																			
0	7	78	12	26		10	AC	90												
1	7	89	12	32		10	AC	80												
2	8	93	12	17		10	SC	23												
3	8	97	13	15		10	SC	14												
4	8	97	14	15		10	SC	25												
5	8	99	13	15		10	SC	29												
6	8	99	13	17		10	SC	3												
7	8	97	17	24		10	SC	3												
8	8	99	18	9		10	SC	4												
9	8	98	22	15		10	SC	4												
10	8	94	23	28		10	SC	5												
11	8	92	24	15		10	SC	5												
12	8	91	23	17		10	SC	5	MS	20										
13	8	94	26	17		10	SC	5	MS	15										
14	8	94	15	13		10	SC	6												
15	8	94	14	15		10	SC	6	MS	25										
16	8	93	15	28		10	SC	6	MS	30										
17	8	88	15	19		5	SC	8	AS	70										
18	8	92	13	17		5	SC	8	SC	30	AC	80								
19	8	93	12	17		0	SC	38	AC	80	AC	80								
20	8	93	14	19		10	SC	38	AC	80										
21	8	93	14	22		10	SC	38	AC	90										
22	8	94	14	15		10	SC	17												
23	8	87	15	15		10	SC	24												

SURFACE WEATHER OBSERVATION AT LONDON ON FEBRUARY 24, 1981

EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100M	TYPE	HT 100M	TYPE	HT 100M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IP
	(DEG C)																			
0	8	93	16	11	9999	10	SC	9												
1	9	91	16	15		10	SC	10	SC	25										
2	10	88	17	17		10	SC	10	SC	26	CU	45								
3	12	98	18	22		10	SC	10	SC	40										
4	9	93	19	15		10	SC	9												
5	10	98	18	17		10	SC	9	SC	40										
6	9	98	18	23		10	SC	15												
7	8	93	18	19		10	SC	12												
8	7	93	19	19		10	SC	8												
9	10	93	19	13		10	ST	5												
10	12	93	20	13		10	ST	5												
11	15	94	20	13		10	ST	7												
12	20	98	23	11		10	ST	8												
13	31	84	23	17		10	CU	11	SC	25										
14	36	78	25	20		9	CU	14	SC	30										
15	37	75	25	24		9	CU	14	SC	30										
16	35	76	24	19		10	SC	10	SC	40										
17	32	82	23	19		9	SC	10	AC	80										
18	32	83	24	20		10	SC	10	SC	30										
19	30	88	24	20		10	SC	10	SC	35										
20	31	81	24	19		10	PL	33												21
21	31	93	27	19		10	SC	13												11
22	-40	91	27	17		10	SC	15												
23	-101	88	27	13		11	SC	25												

[illegible]

[illegible]	CLOUDS	PRECIPITATION
[illegible]	[illegible]	[illegible]

SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 23, 1981

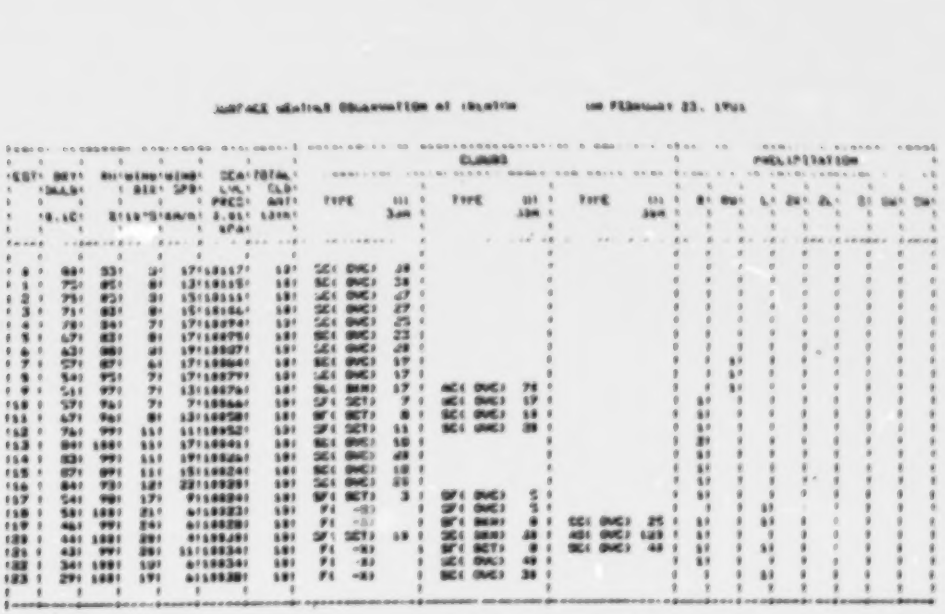
EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100s	TYPE	HT 100s	TYPE	HT 100s	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	07	04	29	26	1007.5	10	SC	030												
1	07	07	29	22	1008.4	10	SC	030												
2	08	06	29	23	1009.3	10	SC	045												
3	05	09	10	28	1009.8	10	SC	035	AC	090										
4	04	07	10	29	1010.4	10	AC	095												
5	02	06	11	19	1010.3	10	SC	025												
6	03	01	10	17	1010.3	10	SC	035												
7	05	00	10	22	1010.7	10	SC	030												
8	07	02	11	26	1009.2	10	SC	030	AC	070										
9	07	07	11	31	1008.7	10	SC	030	AC	070										
10	09	01	11	37	1008.2	10	SC	025												
11	09	03	11	28	1008.1	10	SC	025	AC	090										
12	08	00	14	26	1008.0	10	FI	03	SC	040	CB	080								
13	09	09	26	19	1006.7	10	CU	007	SC	040	AC	070								
14	05	02	23	15	1006.7	10	AC	040	SC	040	AC	080								
15	06	01	23	11	1008.1	10	CF	007	SC	012	SC	040								
16	04	01	22	11	1008.7	10	AC	040	SC	070	AS	090								
17	03	09	21	9	1008.8	10	SC	040	AC	080										
18	04	09	19	6	1008.7	10	CU	007	SC	015	SC	025	AC	090						
19	04	09	19	7	1008.6	10	CU	007	SC	015	SC	040								
20	03	01	18	7	1008.5	10	AC	090												
21	03	03	16	7	1008.9	7	SC	040												
22	04	02	15	7	1008.8	2	SC	012												
23	04	04	14	11	1008.2	10	FI	03												

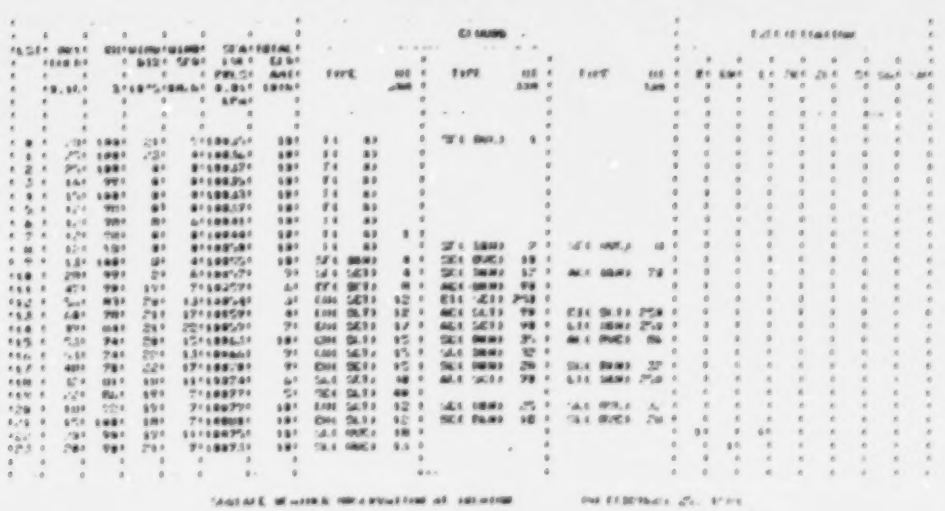
SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 24, 1981

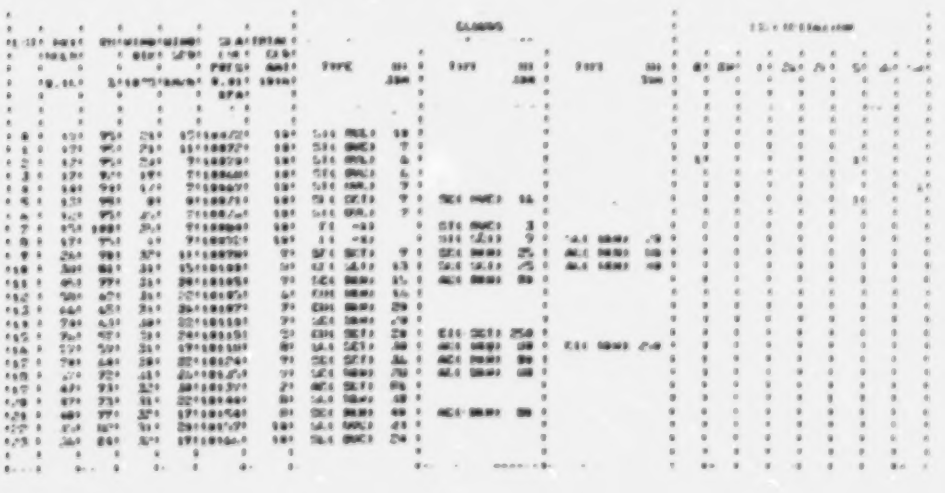
EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100s	TYPE	HT 100s	TYPE	HT 100s	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	12	09	14	7	1013.9	10	FI	03	SC	070										
1	12	08	14	6	1013.5	10	FI	03	CF	030	SC	030								
2	10	06	14	7	1013.5	10	FI	03	CF	030										
3	12	09	12	9	1013.9	9	SC	040												
4	10	06	12	7	1013.9	7	SC	040												
5	12	09	12	6	1014.0	10	SC	040												
6	12	09	14	7	1014.0	10	SC	040												
7	14	07	15	7	1013.3	7	SC	040												
8	15	08	15	7	1013.3	9	SC	035	AC	130	AC	150								
9	24	05	19	6	1012.8	10	SC	040	AC	090										
10	08	07	22	11	1010.3	9	CF	025	SC	045	AC	095								
11	08	04	23	20	1008.8	9	CU	016	AC	095										
12	08	01	23	17	1009.3	10	CF	013	SC	040	AC	090								
13	09	08	23	13	1009.2	10	CF	014	SC	040										
14	05	07	22	15	1009.2	10	AC	025	SC	040	AC	095								
15	08	07	21	11	1009.2	9	CU	017	SC	037										
16	09	08	16	9	1009.5	10	SC	040	SC	040										
17	03	03	22	11	1009.8	10	CF	013	SC	040										
18	08	02	22	15	1009.8	10	SC	040												
19	08	05	22	11	1009.7	10	SC	040												
20	06	06	22	15	1009.7	10	SC	040												
21	09	09	22	19	1008.9	10	ST	007												
22	10	06	22	15	1008.8	10	ST	007												
23	15	09	20	20	1008.8	8	SC	040												

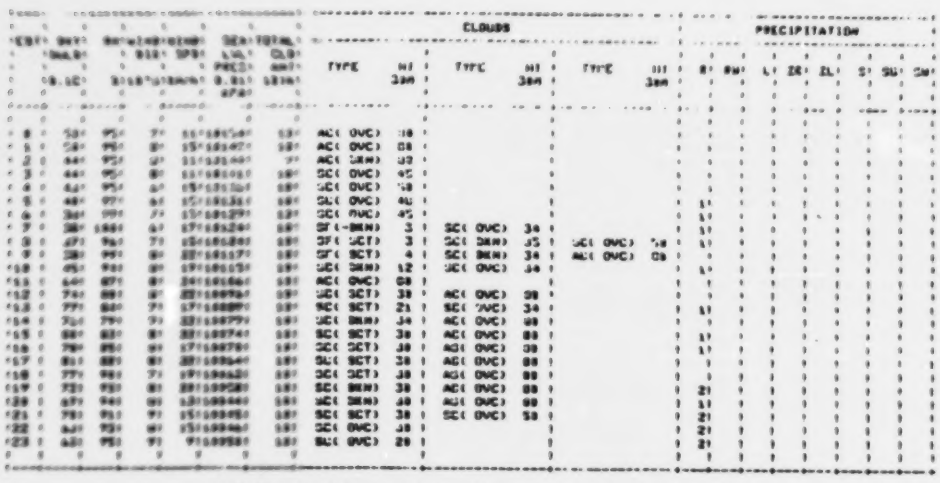
SURFACE WEATHER OBSERVATION AT TORONTO ON FEBRUARY 25, 1981

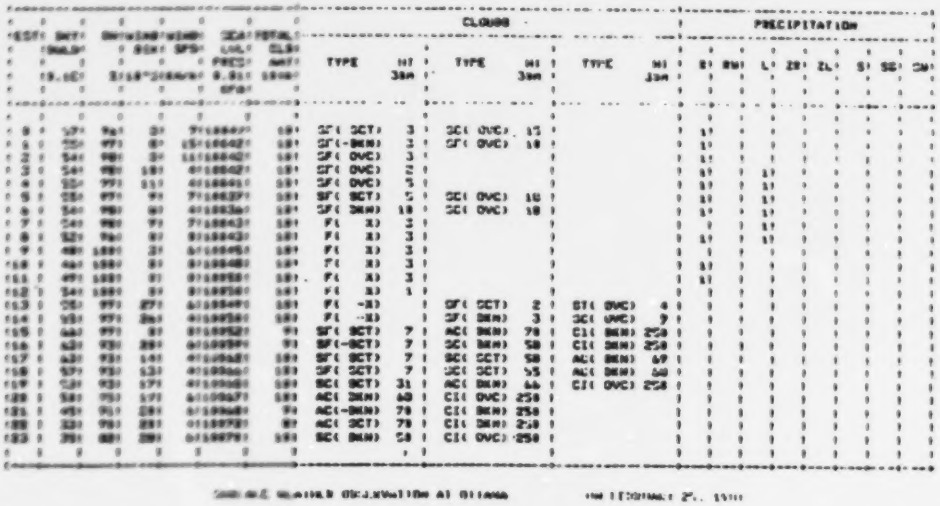
EST	DRY	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100s	TYPE	HT 100s	TYPE	HT 100s	PRECIPITATION R	RW	L	ZR	ZL	S	SG	CH
0	01	00	29	24	1008.8	10	SC	030	AC	090										
1	01	00	29	28	1008.7	10	SC	030	AC	090										
2	01	00	29	26	1008.8	10	SC	030												
3	01	01	29	28	1008.8	10	SC	030												
4	00	00	29	29	1008.8	10	SC	030												
5	01	00	29	19	1008.8	10	SC	030												
6	01	00	29	13	1010.1	10	SC	030	SC	040										
7	01	00	29	17	1010.5	10	SC	030	SC	040										
8	01	00	30	26	1010.1	9	CF	025	SC	035	SC	080	AC	090						
9	01	00	30	17	1010.8	10	SC	030	AC	090										
10	01	00	30	24	1010.6	10	SC	030	AC	090										
11	00	00	30	28	1010.5	10	SC	030	AC	090										
12	02	01	30	24	1010.6	10	SC	030	AC	090										
13	04	00	30	30	1010.5	10	SC	030	AC	090										
14	03	00	30	26	1010.5	10	SC	030	SC	040	AC	090								
15	03	00	30	31	1010.5	10	SC	030	AC	090										
16	03	01	30	37	1010.5	10	SC	030												
17	02	00	30	24	1010.5	10	SC	030												
18	02	00	30	24	1010.7	10	SC	030												
19	03	01	30	30	1010.5	10	SC	030	SC	040										
20	01	00	30	24	1010.5	10	SC	030												
21	01	00	30	22	1010.5	10	SC	030												
22	01	00	30	24	1010.5	10	SC	030												
23	01	00	30	22	1010.5	10	SC	030												

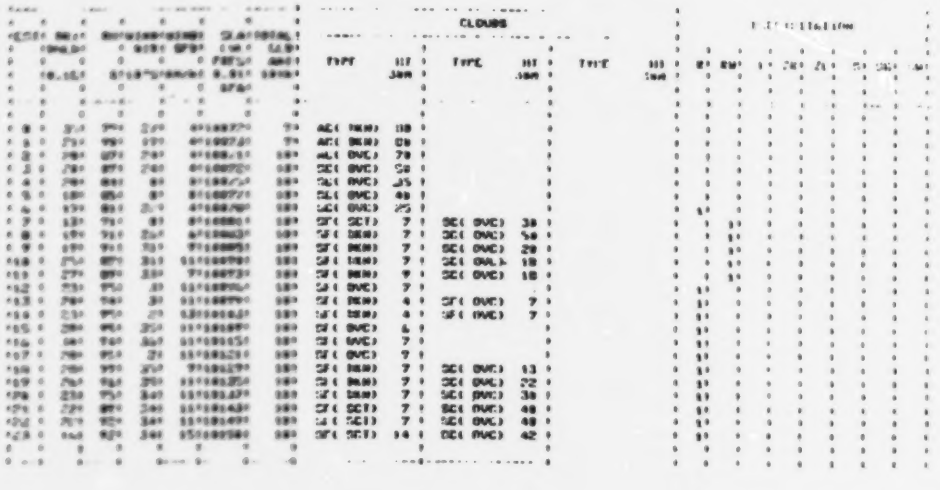












SURFACE WEATHER OBSERVATION AT PETAWAWA ON FEBRUARY 23, 1981

EST	DRY BULB	DEW PT	WIND DIR	WIND SPD	SEA LVL PRES 0.01 KPA	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-22	93	11	9	10138	10	AC	OVC	45											
1	-18	93	13	7	10123	10	AC	OVC	45											
2	-16	91	14	11	10123	10	AC	OVC	45											
3	-20	87	14	13	10117	10	SC	OVC	40											
4	-13	98	13	17	10140	10	ST	OVC	10											
5	-22	98	15	19	10189	10	ST	OVC	10											
6	-19	89	15	19	10184	10	SC	OVC	30											
7	-16	89	15	13	10099	10	ST	SCT	8	SC	OVC	30								
8	-18	88	15	17	10101	10	ST	SCT	8	SC	OVC	30								
9	-19	87	15	19	10091	10	ST	SCT	10	SC	OVC	30								
10	-17	89	15	17	10088	10	SF	BKN	10	SC	OVC	30			L					
11	-18	93	15	15	10086	10	ST	BKN	10	SC	OVC	30			L					
12	-20	91	16	13	10077	10	SF	SCT	10	SC	OVC	30								
13	-18	93	15	15	10071	10	ST	BKN	9	SC	OVC	30			L					
14	-16	94	15	15	10064	10	SF	SCT	9	SC	OVC	25			L					
15	-14	95	14	9	10057	10	SF	SCT	9	SC	OVC	25			L					
16	-17	95	14	7	10048	10	SF	SCT	9	SC	OVC	25			L					
17	-18	95	13	7	10043	10	FG	-X		SF	OVC	4			L					
18	-11	96	14	15	10036	10	SF	BKN	6	SC	OVC	10			L					
19	-11	94	13	11	10028	10	SF	OVC	8						L					
20	-10	96	14	17	10022	10	SF	OVC	8						L					
21	-10	97	14	19	10023	10	FG	X	5							L				
22	-10	98	14	20	10019	10	SF	OVC	5						L					
23	-11	96	14	19	10019	10	SF	OVC	6						L					

SURFACE WEATHER OBSERVATION AT PETAWAWA ON FEBRUARY 24, 1981

EST	DRY BULB	DEW PT	WIND DIR	WIND SPD	SEA LVL PRES 0.01 KPA	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-14	95	14	15	10082	10	SF	OVC	5											
1	-13	96	12	9	10082	10	FG	X	2											
2	-14	95	12	9	10082	10	FG	X	1											
3	-19	95	13	11	10086	10	FG	X	1											
4	-17	96	13	6	10082	10	FG	X							L					
5	-27	98	14	6	10080	10	FG	-X							L					
6	-24	96	25	6	10084	10	FG	-X							L					
7	-15	95	27	6	10084	10	FG	X		SC	OVC	20			L					
8	-21	100	31	8	10090	9	FG	-X		SC	OVC	20	CU	BKN	200					
9	-16	96	31	8	10094	9	FG	-X		SC	OVC	20	AC	BKN	80					
10	-19	92	28	7	10097	9	FG	-X		SC	OVC	20	AC	BKN	80					
11	-18	94	12	7	10095	8	CU	SCT	10	SF	SCT	2	AC	SCT	80					
12	-17	88	12	6	10097	9	CU	SCT	15	AC	BKN	80	CI	BKN	200					
13	-18	82	12	9	10094	8	CU	SCT	15	AC	BKN	80	CI	BKN	200					
14	-20	75	13	13	10093	9	CU	SCT	16	AC	SCT	80	CI	BKN	200					
15	-16	87	12	9	10095	9	CU	SCT	20	AC	BKN	80	CI	BKN	200					
16	-17	87	28	13	10090	9	SC	SCT	20	AC	BKN	80	CI	BKN	200					
17	-18	88	17	13	10085	9	SC	SCT	20	AC	BKN	80	CI	BKN	200					
18	-18	73	26	9	10097	10	SC	SCT	20	AC	BKN	80	CI	BKN	200					
19	-15	69	16	6	10086	10	SC	SCT	20	AC	OVC	80								
20	-11	79	16	6	10082	10	AC	OVC	75											
21	-27	81	9	6	10086	10	AC	OVC	80											
22	-13	87	9	6	10086	10	AC	OVC	80											
23	-23	82	12	7	10086	6	AC	BKN	100											

[illegible] WEATHER OBSERVATION AT PETAWAWA [illegible]

EST	DRY BULB	DEW PT	WIND DIR	WIND SPD	SEA LVL PRES 0.01 KPA	TOTAL CLD AMT	CLOUDS TYPE	HT 30M	TYPE	HT 30M	TYPE	HT 30M	PRECIPITATION R	RW	L	ZR	ZL	S	SG	SW
0	-24	84	11	6	10086	10	AC	OVC	100											
1	-23	81	11	7	10086	10	AC	OVC	100											
2	-25	83	11	6	10078	10	AC	OVC	100											
3	-25	84	9	9	10078	9	AC	BKN	100											
4	-8	98	8	8	10074	10	AC	OVC	100											
5	-23	97	28	6	10080	21	AC	SCT	100											
6	-23	91	8	8	10080	10	AC	OVC	100											
7	-18	93	28	6	10092	10	AC	SCT	100	CI	OVC	200								
8	-9	79	8	8	10090	10	SC	SCT	30	AC	BKN	120	CI	OVC	200					
9	-7	78	29	7	10101	10	SC	BKN	35	AC	OVC	80								
10	-22	87	30	13	10101	10	SC	SCT	40	CI	OVC	200								
11	-19	82	33	15	10106	10	ST	SCT	8	SC	BKN	50	CI	OVC	200					
12	-11	82	32	13	10107	10	ST	SCT	12	SC	OVC	30								
13	-21	76	33	13	10108	10	SC	SCT	20	CI	OVC	200								
14	-17	69	31	20	10112	10	SC	SCT	20	CI	OVC	200								
15	-19	67	32	19	10116	10	SC	SCT	20	AC	SCT	120	CI	OVC	200					
16	-20	75	33	19	10126	10	SC	BKN	20	AC	OVC	100								
17	-17	80	33	22	10132	10	SC	BKN	20	AC	OVC	100								
18	-19	87	33	15	10101	10	SC	BKN	20	AC	OVC	100								
19	-20	86	32	15	10102	10	SC	BKN	17	AC	OVC	90								
20	-18	87	31	17	10106	10	SC	OVC	20											
21	-18	87	31	17	10106	10	SF	SCT	10	AC	OVC	70								
22	-17	81	33	13	10102	10	SC	SCT	15	SC	OVC	19								
23	-13	79	32	11	10102	10	SF	SCT	15	SC	OVC	20								

SURFACE WEATHER OBSERVATION AT KAPUSKASING ON FEBRUARY 23, 1981

EST	DRY BULB	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IW
	DEG C	DEG C	10'S DEG	KM/H	0.01 KPA	10THS		100S M		100S M		100S M								
0	35	74	12	15	100720	10	SF	7	SC	11										
1	34	95	12	9	100641	10	SF	5												
2	30	99	11	15	100581	10	SF	3												
3	36	98	11	15	100640	10	FG	0												
4	33	99	12	11	100640	10	FG	0												
5	47	99	11	13	100630	10	SF	3	SC	6										
6	46	98	12	17	100620	10	SF	2	SF	4	SC	7								
7	46	99	12	15	100625	10	SF	4	SF	7										
8	43	100	14	19	100627	10	SF	4												
9	47	98	14	28	100617	10	SF	4												
10	52	97	14	22	100611	10	SF	2	SF	4										
11	51	98	14	28	100600	10	SF	3	SF	4										
12	51	95	13	19	100583	10	SF	4												
13	56	96	14	15	100565	10	SF	4	SF	6										
14	46	98	13	13	99790	10	SF	4	SF	6										
15	45	98	13	11	99792	10	SF	4	SF	6										
16	52	98	12	13	99787	10	SF	4												
17	44	99	12	11	99787	10	SF	5												
18	44	98	12	9	99787	10	SF	5												
19	42	97	12	9	99784	10	SF	5												
20	42	97	12	9	99777	10	SF	4	SF	5										
21	40	98	12	17	99771	10	SF	3	SF	4										
22	38	98	12	11	99765	10	SF	2	SF	3										
23	38	100	12	13	99758	10	FG	0												

SURFACE WEATHER OBSERVATION AT KAPUSKASING ON FEBRUARY 24, 1981

EST	DRY BULB	DEW	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT	TYPE	HT	TYPE	HT	PRECIPITATION R	RW	L	ZR	ZL	S	SG	IW
	DEG C	DEG C	10'S DEG	KM/H	0.01 KPA	10THS		100S M		100S M		100S M								
0	38	100	14	19	99753	10	SF	3	SF	6										
1	44	97	14	17	99747	10	SF	3	SF	6										
2	48	95	17	19	99755	10	SF	6	SF	10	SC	23								
3	33	92	28	22	99758	10	SF	6	SF	10	SC	16								
4	23	91	29	24	99762	10	SF	8	SF	14	SC	23								
5	17	92	29	22	99765	10	SF	8	SF	15	SC	23								
6	12	90	30	24	99770	8														
7	7	90	30	19	99772	8														
8	7	86	17	17	99780	10	SC	11												
9	28	98	16	28	99811	8	SC	40												
10	35	83	19	26	99771	8	CF	13	SC	40										
11	34	85	16	26	99808	10	SC	12												
12	30	88	17	24	99844	10	SC	12												
13	33	95	16	24	99905	10	SC	16												
14	32	88	17	19	99927	10	SC	15												
15	32	87	16	17	99958	10	SF	10	SC	15	SC	30								
16	14	98	17	11	100000	9	SF	7	SF	12	SC	22								
17	12	94	15	7	100019	10	SF	7	SF	17										
18	10	96	17	6	100038	10	SF	7	SF	14	SC	30								
19	10	96	0	0	100038	9	SF	7	SF	14	SC	28								
20	9	90	33	9	100058	10	SF	10												
21	3	90	31	15	100058	10	SF	10	SC	15	SC	30								
22	-2	90	30	19	100048	10	SF	12	SC	33										
23	-9	85	33	22	100008	10	SC	29												

[illegible]

0	[illegible]	31	28	[illegible]	10	SC	10													
1	[illegible]	32	24	[illegible]	10	SC	10													
2	[illegible]	31	27	[illegible]	10	SC	17													
3	[illegible]	31	28	[illegible]	10	SC	16	SC	25	SC	42									
4	[illegible]	32	24	[illegible]	10	SC	17													
5	[illegible]	32	26	[illegible]	10	SC	23													
6	[illegible]	34	17	[illegible]	10	SC	25													
7	[illegible]	34	17	[illegible]	10	SC	28													
8	[illegible]	36	15	[illegible]	10	SC	10													
9	[illegible]	36	15	[illegible]	10	SC	10													
10	[illegible]	36	22	[illegible]	9	SC	28													
11	[illegible]	37	28	[illegible]	6	SC	22													
12	[illegible]	33	13	[illegible]	6	SC	25													
13	[illegible]	33	13	[illegible]	6	SC	32													
14	[illegible]	34	15	[illegible]	6	SC	42													
15	[illegible]	35	17	[illegible]	6	SC	34													
16	[illegible]	33	17	[illegible]	7	SC	38													
17	[illegible]	35	17	[illegible]	7	SC	35													
18	[illegible]	36	5	[illegible]	9	SC	28													
19	[illegible]	37	19	[illegible]	9	SC	24													
20	[illegible]	37	22	[illegible]	10	SC	22													
21	[illegible]	37	19	[illegible]	10	SC	29													
22	[illegible]	38	5	[illegible]	10	SC	29													
23	[illegible]	39	19	[illegible]	10	SC	29													

SURFACE WEATHER OBSERVATION AT SILVER LAKEOUT ON FEBRUARY 23, 1981

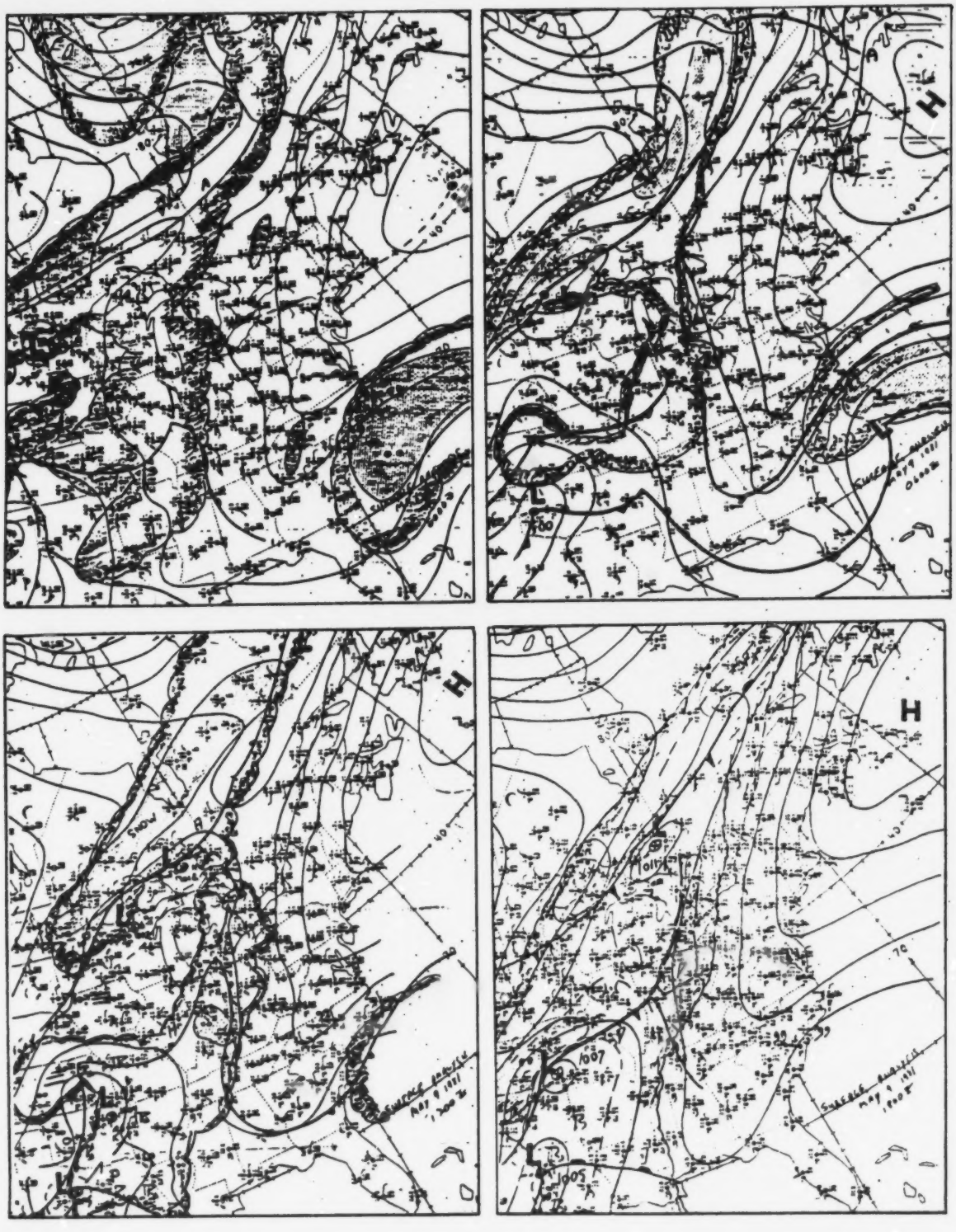
EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100s	TYPE	HT 100s	TYPE	HT 100s	PRECIPITATION 5'	60'	1'	2'	3'	6'	12'	24'
0	0°	77%	35°	15	29.07	10	SC(BKN)	08	AC(OVC)	50										
1	18°	70%	35°	17	29.08	10	SC(BKN)	20	AC(OVC)	80										
2	13°	80%	35°	17	29.08	10	SC(SCT)	15	SC(BKN)	40	AC(OVC)	40								
3	14°	82%	34°	17	29.07	10	SC(SCT)	15	SC(OVC)	25										
4	21°	87%	34°	17	29.08	10	SC(SCT)	12	SC(BKN)	15										
5	-5°	89%	35°	17	29.05	10	FG	03												
6	-8°	89%	35°	17	29.05	10	FG	03												
7	-27°	89%	35°	15	29.05	10	FG	03	SC(BKN)	10	SC(OVC)	20								
8	-29°	90%	35°	15	29.05	10	FG	03	SC(BKN)	10	SC(OVC)	20								
9	-26°	89%	35°	17	29.05	10	FG	03	SC(SCT)	12	SC(OVC)	20								
10	-25°	90%	35°	17	29.05	10	FG	03	SC(SCT)	12	SC(OVC)	20								
11	-24°	82%	35°	22	29.05	10	SC(-SCT)	12	SC(OVC)	20										
12	20°	79%	35°	22	29.05	10	SC(-BKN)	14	SC(OVC)	20										
13	-15°	77%	34°	22	29.05	10	SC(-SCT)	14	SC(OVC)	20										
14	-18°	78%	34°	15	29.05	10	SC(SCT)	20	SC(-BKN)	40	AC(BKN)	80								
15	-18°	74%	34°	13	29.05	10	SC(SCT)	24	SC(-BKN)	40	AC(BKN)	80								
16	-6°	71%	34°	11	29.05	10	AC(-BKN)	60	CI(BKN)	220										
17	-5°	71%	32°	15	29.04	10	AC(SCT)	80	CI(-BKN)	220										
18	-22°	75%	34°	4	29.04	5	AC(SCT)	80	CI(-SCT)	220										
19	-34°	83%	0°	0	29.04	2	CI(-SCT)	220												
20	6°	91%	0°	0	29.03	0														
21	-46°	88%	0°	0	29.03	7	SC(-BKN)	15												
22	-48°	88%	14°	0	29.02	10	SC(SCT)	12	SC(OVC)	40										
23	-36°	87%	16°	2	29.01	10	SC(OVC)	40												

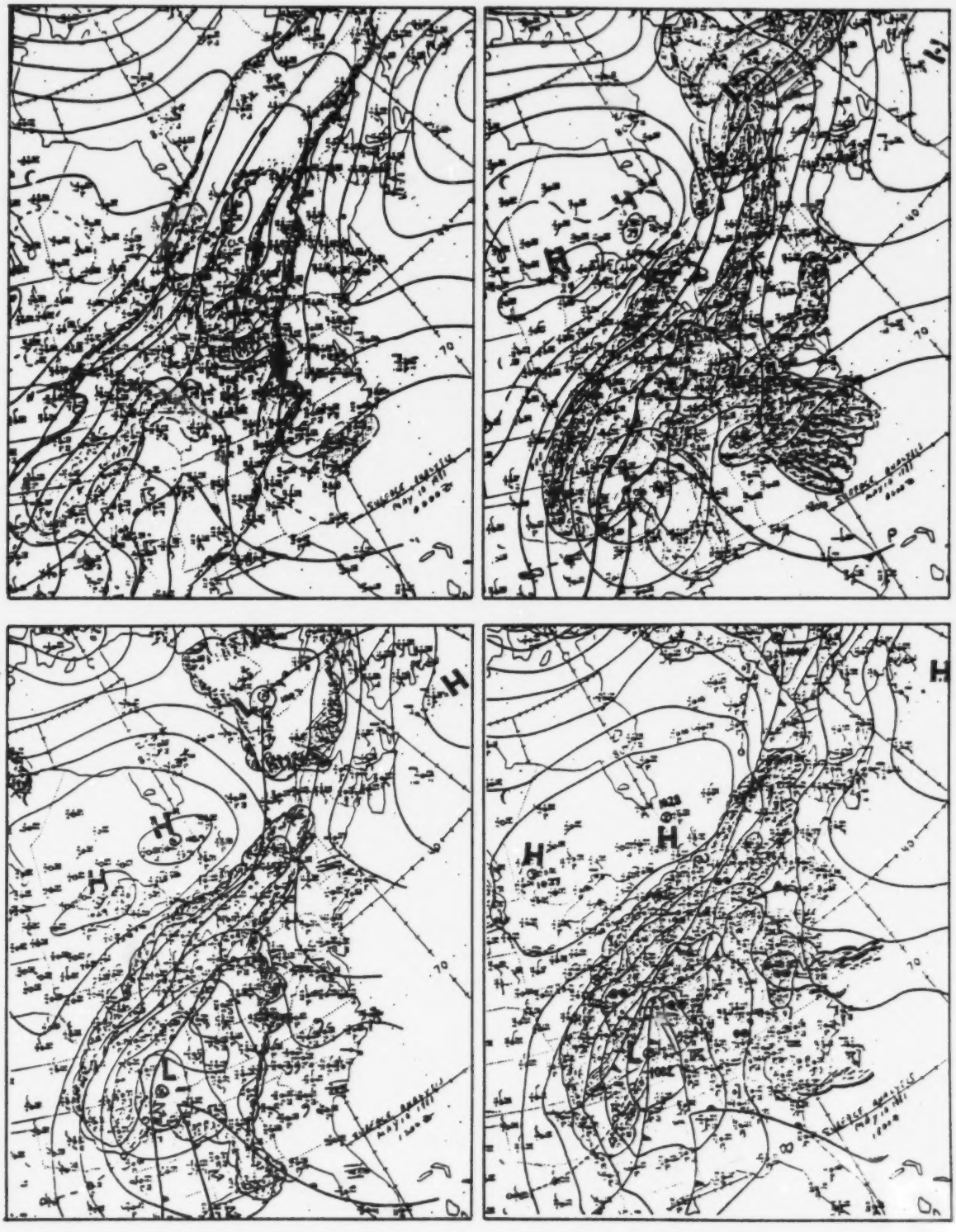
SURFACE WEATHER OBSERVATION AT SILVER LOCKOUT ON FEBRUARY 24, 1981

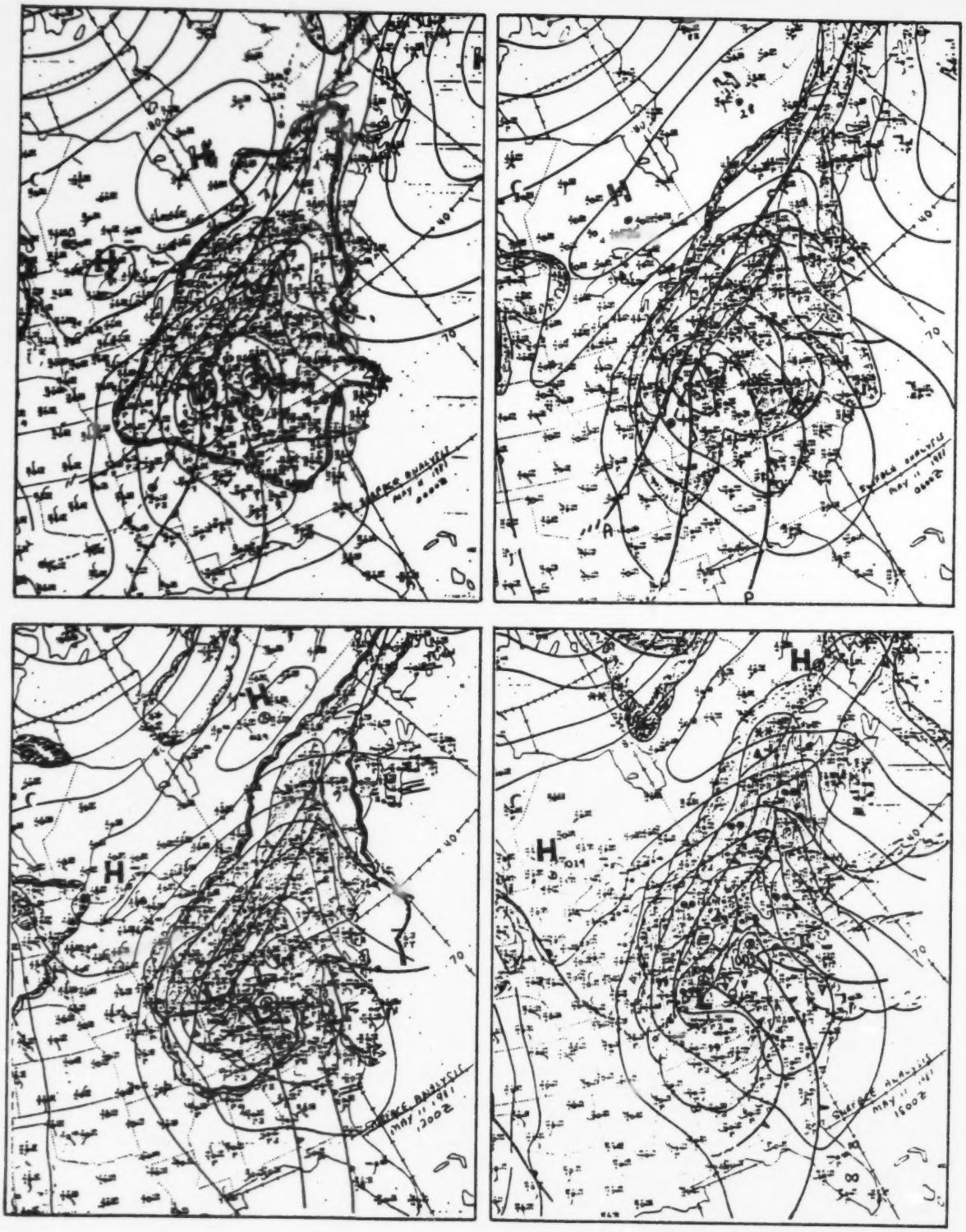
EST	DRY BULB	RH	WIND DIR	WIND SPD	SEA LVL PRES	TOTAL CLD AMT	CLOUDS TYPE	HT 100s	TYPE	HT 100s	TYPE	HT 100s	PRECIPITATION 5'	60'	1'	2'	3'	6'	12'	24'
0	6°	87%	15°	4	29.08	10	SC(BKN)	25	SC(OVC)	40										
1	-3°	87%	17°	6	29.07	10	SC(BKN)	15	SC(OVC)	24										
2	-22°	92%	31°	17	29.07	10	FG	03	SC(OVC)	15										
3	-24°	90%	30°	22	29.07	10	FG	03	SC(OVC)	15										
4	-26°	89%	32°	22	29.07	10	FG	03	SC(OVC)	15										
5	-34°	90%	36°	17	29.08	10	FG	03	SC(OVC)	17										
6	-30°	89%	35°	17	29.08	10	FG	03												
7	-42°	87%	34°	22	29.08	10	FG	03	SC(OVC)	15										
8	-44°	87%	34°	22	29.08	10	FG	03	SC(OVC)	15										
9	-45°	83%	35°	17	29.08	10	SC(OVC)	15												
10	-43°	81%	33°	22	29.08	10	SC(SCT)	15	SC(BKN)	25	AC(OVC)	40								
11	-49°	80%	32°	22	29.07	10	SC(SCT)	15	SC(BKN)	60	AC(OVC)	70								
12	-49°	79%	33°	26	29.08	10	AC(OVC)	15												
13	-43°	76%	34°	22	29.09	10	SC(OVC)	19												
14	-48°	77%	31°	22	29.10	10	SC(OVC)	20												
15	-52°	79%	33°	17	29.11	10	SC(OVC)	20												
16	-50°	76%	32°	17	29.12	10	SC(OVC)	20												
17	-48°	74%	30°	13	29.12	10	SC(OVC)	20												
18	-42°	77%	29°	22	29.10	10	SC(OVC)	17												
19	-44°	78%	32°	9	29.10	10	SC(OVC)	23												
20	-46°	78%	32°	22	29.10	10	SC(OVC)	15												
21	-48°	77%	32°	15	29.10	10	SC(SCT)	15	SC(OVC)	20										
22	-48°	77%	30°	15	29.10	10	SC(SCT)	15	SC(OVC)	20										
23	-48°	77%	30°	13	29.10	10	SC(SCT)	15	SC(OVC)	40										

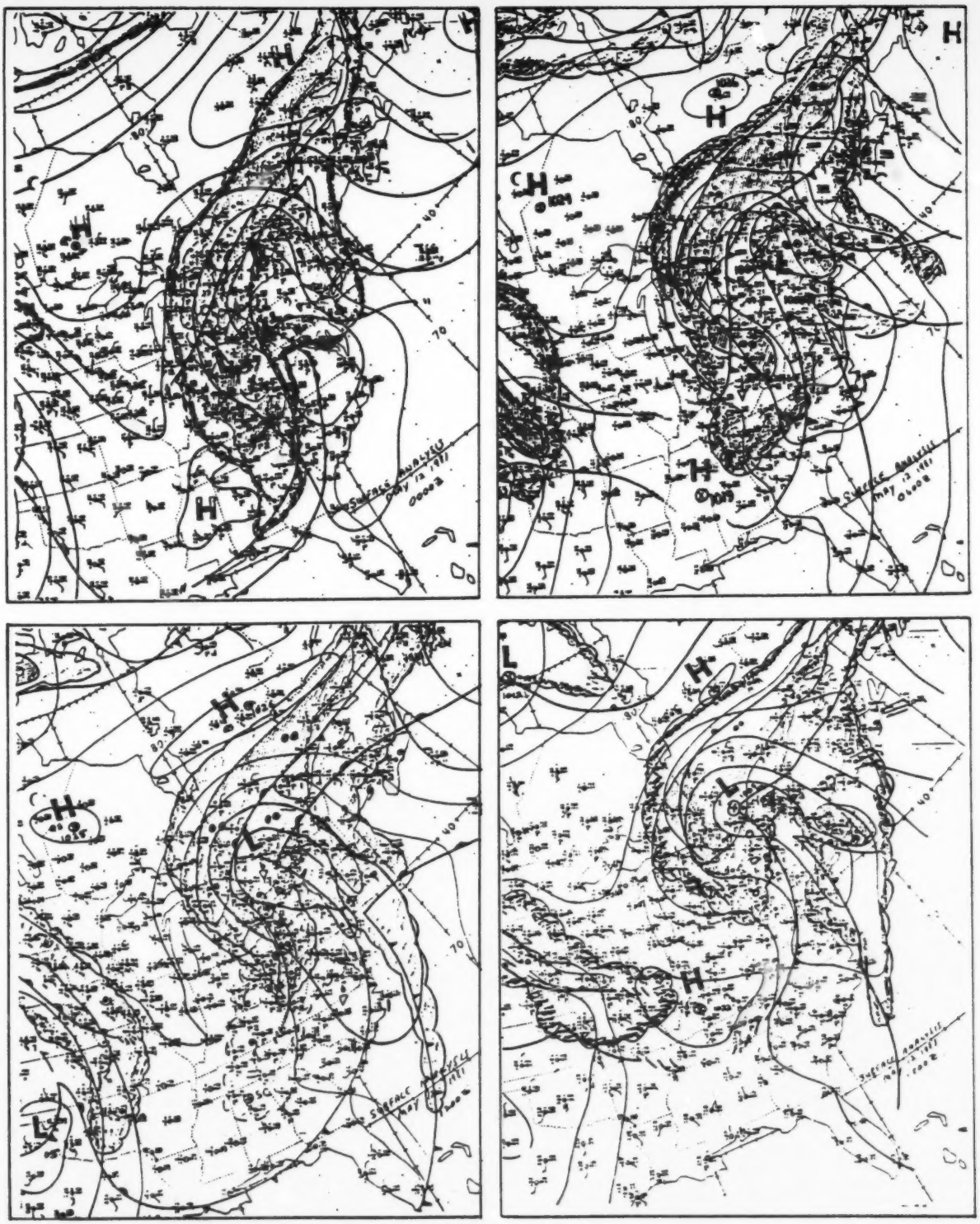
APPENDIX D

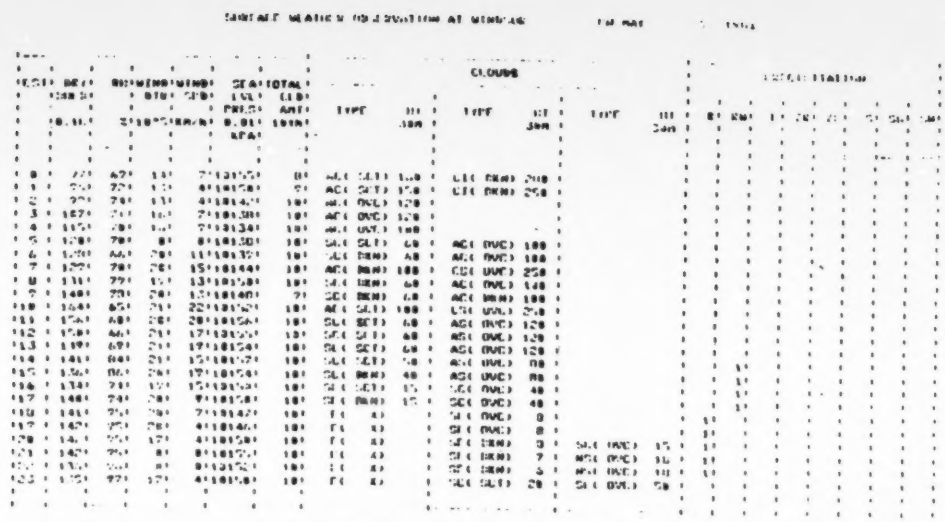
SURFACE SYNOPTIC WEATHER MAPS AND OBSERVATIONAL DATA FOR PRECIPITATION EPISODE 4: MAY 9 TO 12, 1981

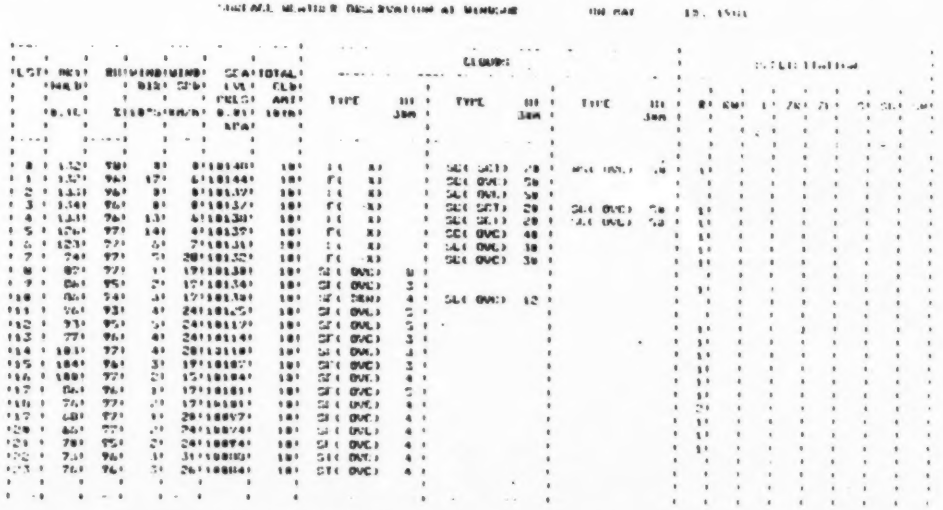

H
H
H

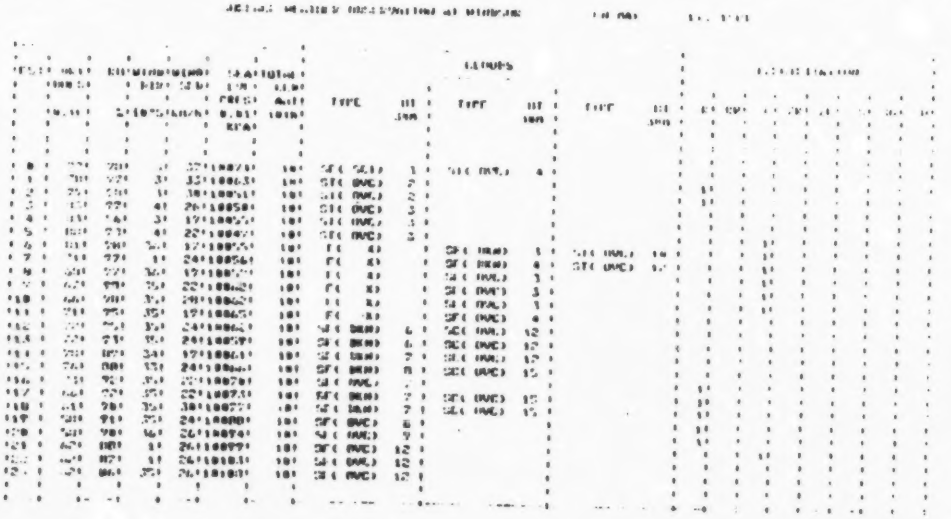


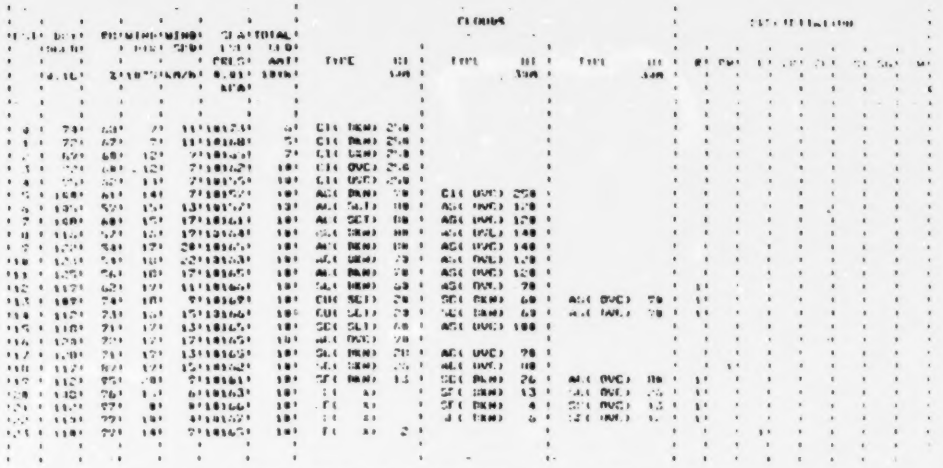


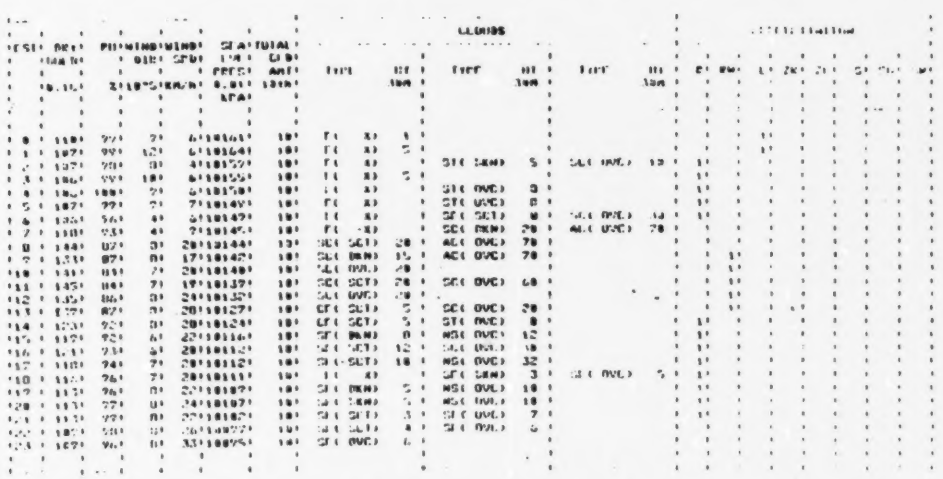


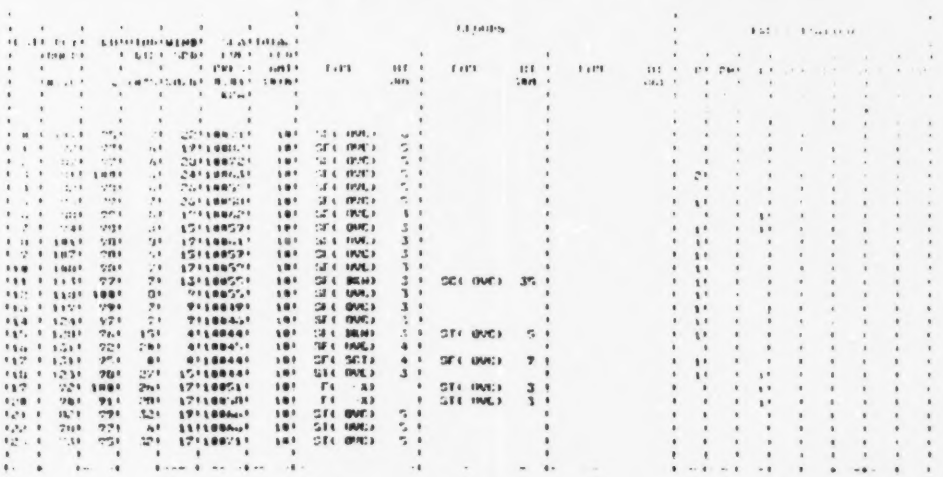


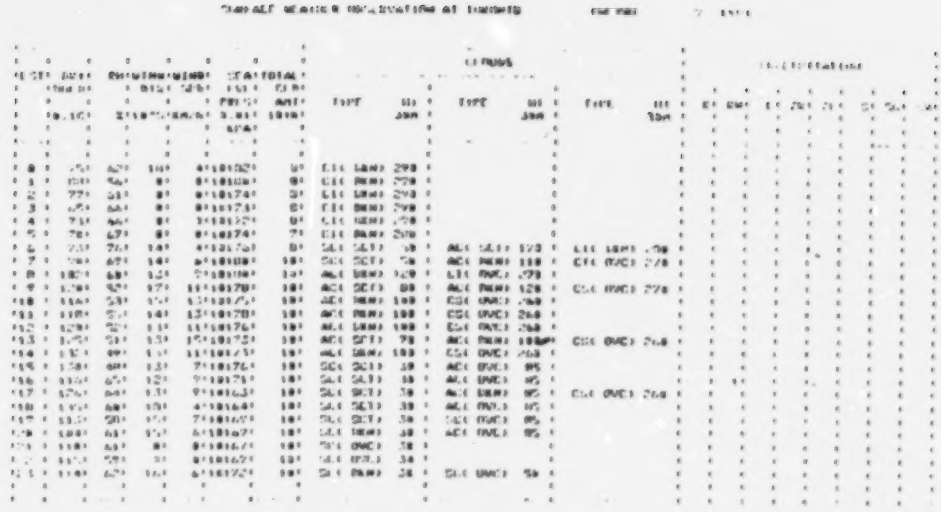


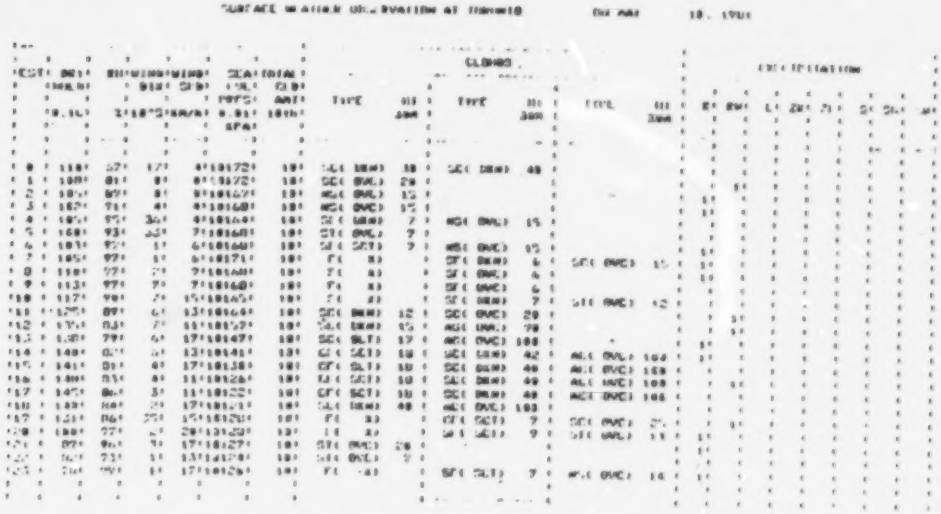


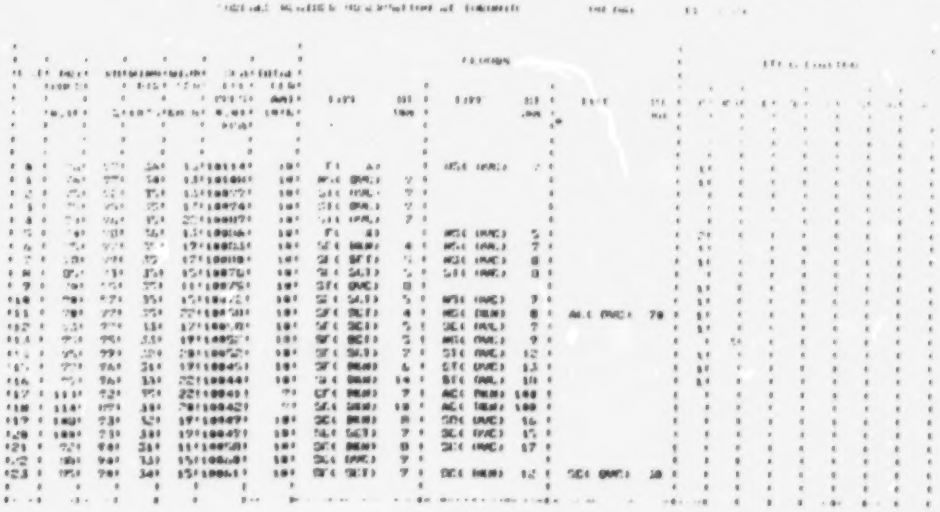


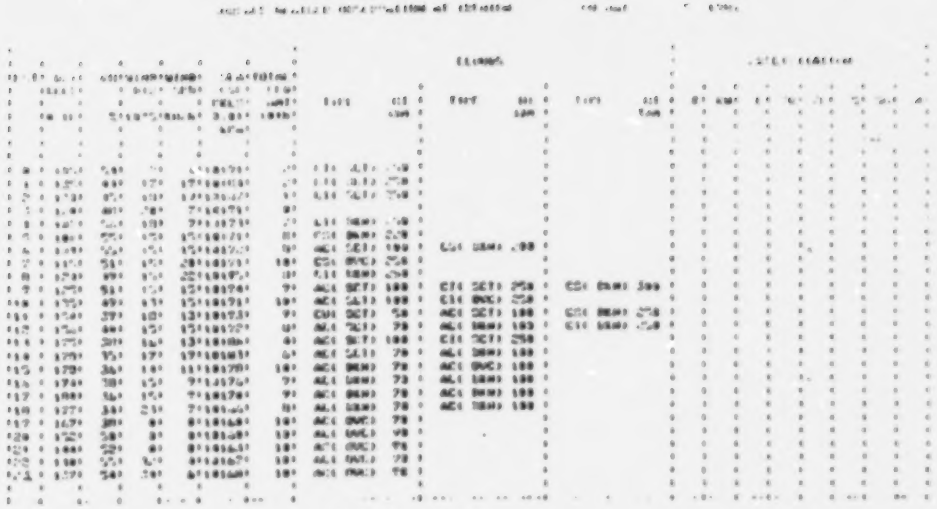


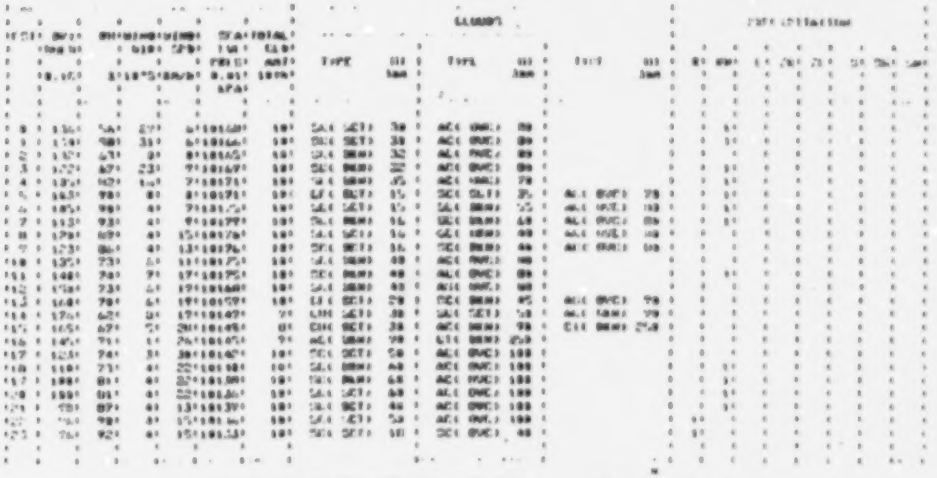


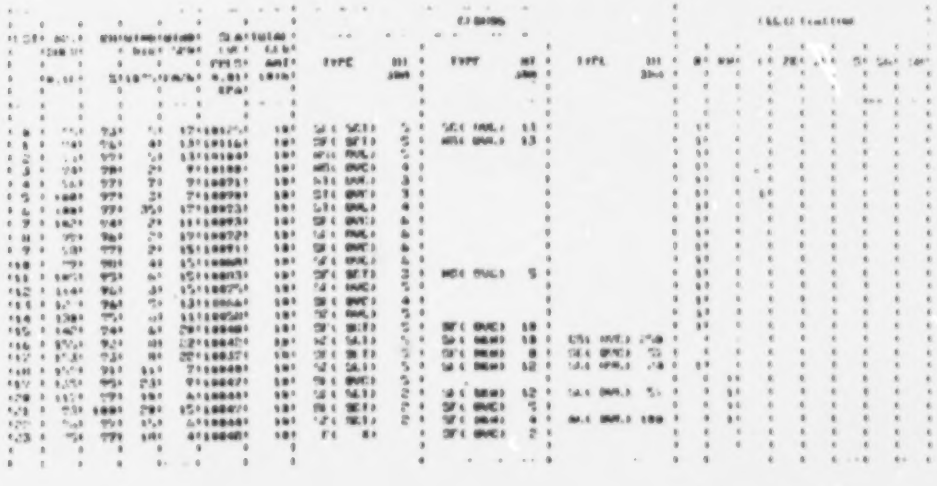


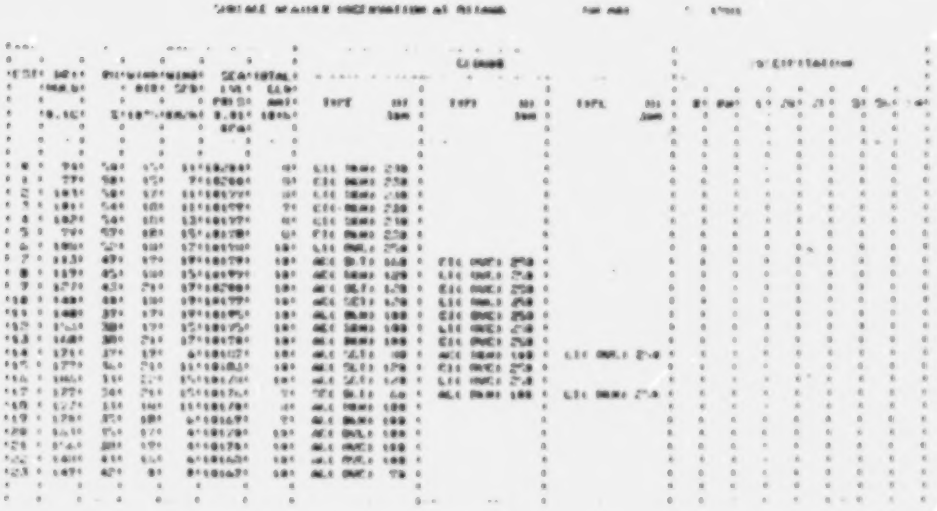


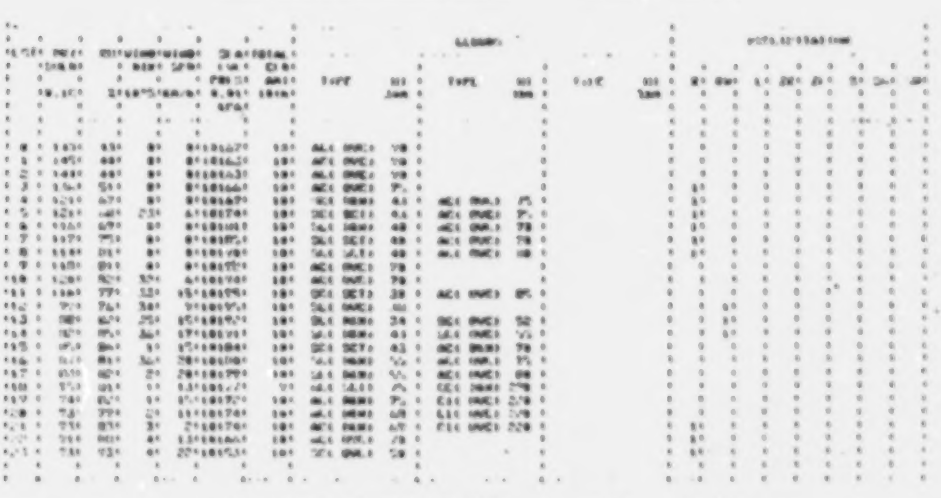


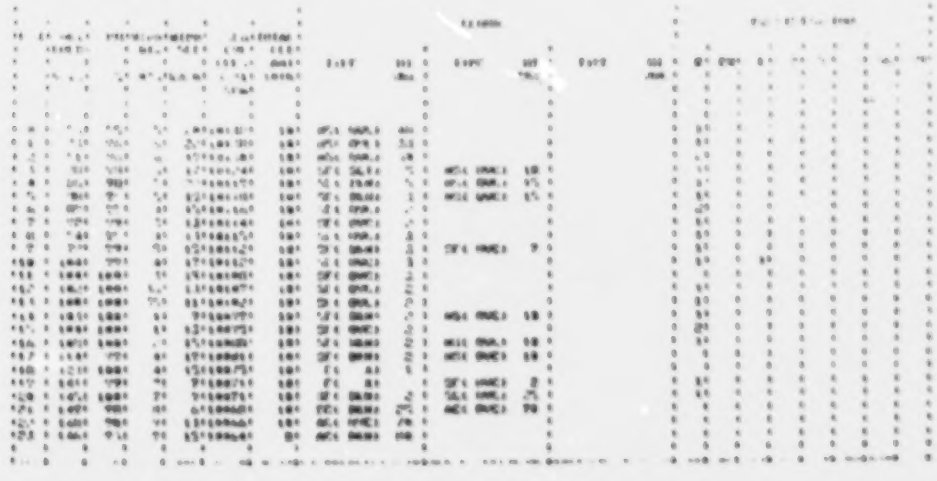


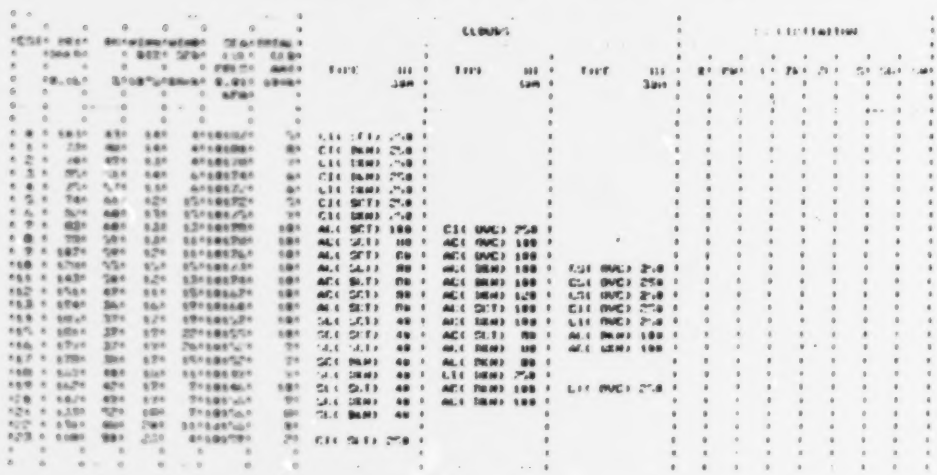


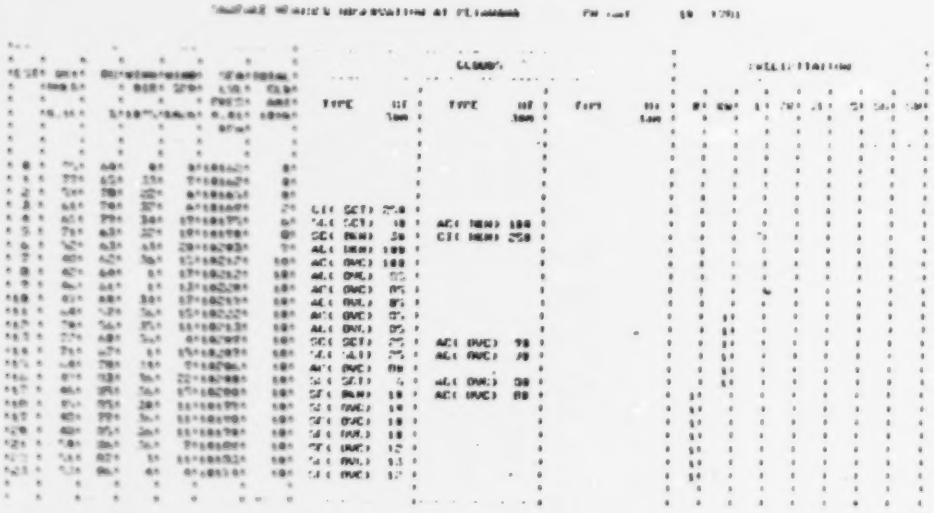


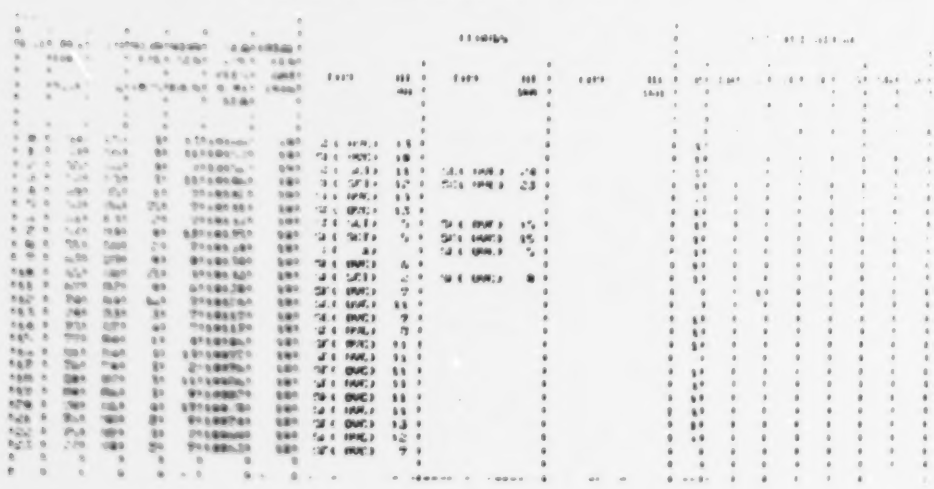


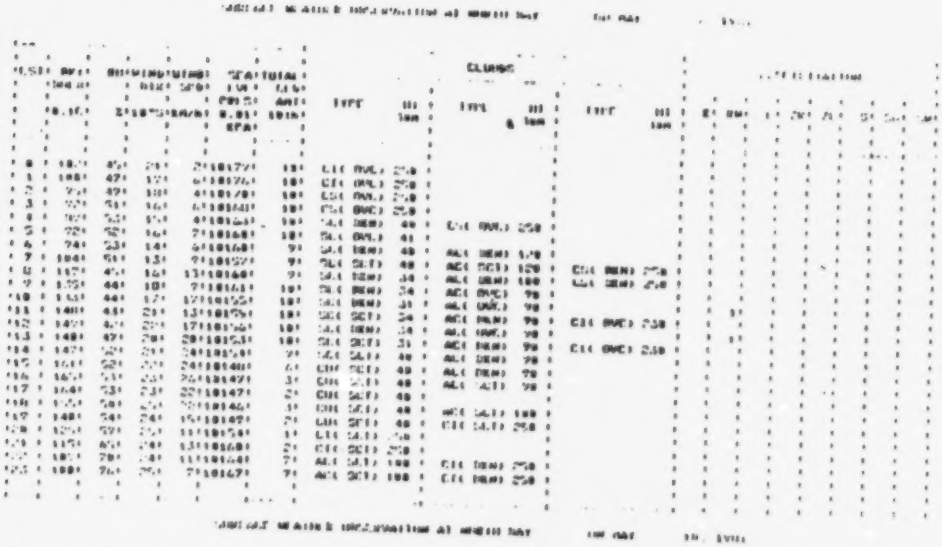


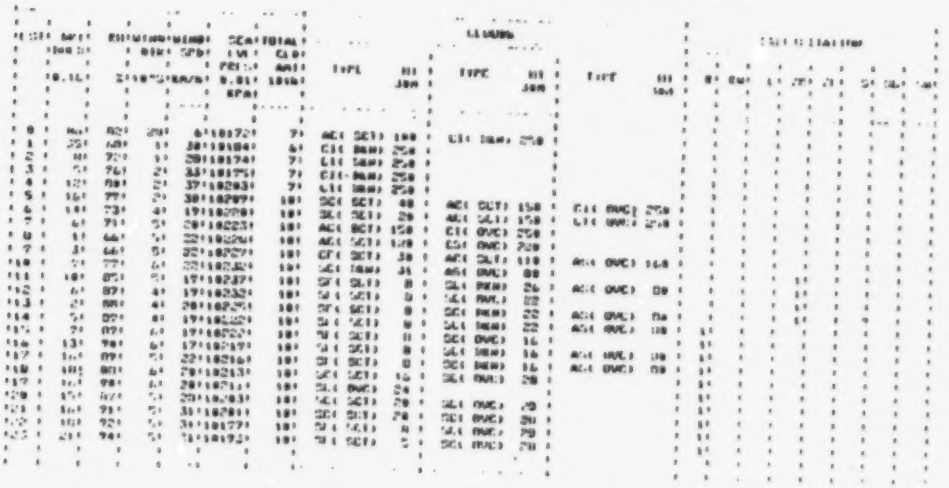


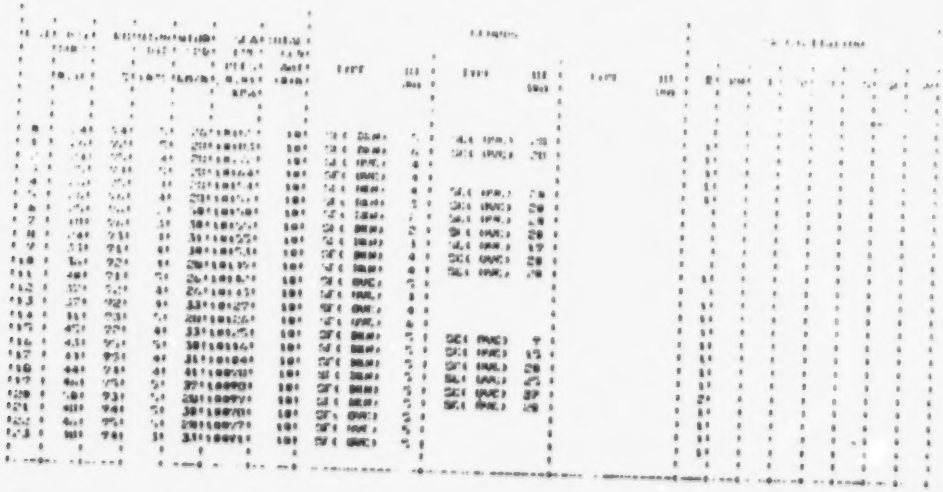


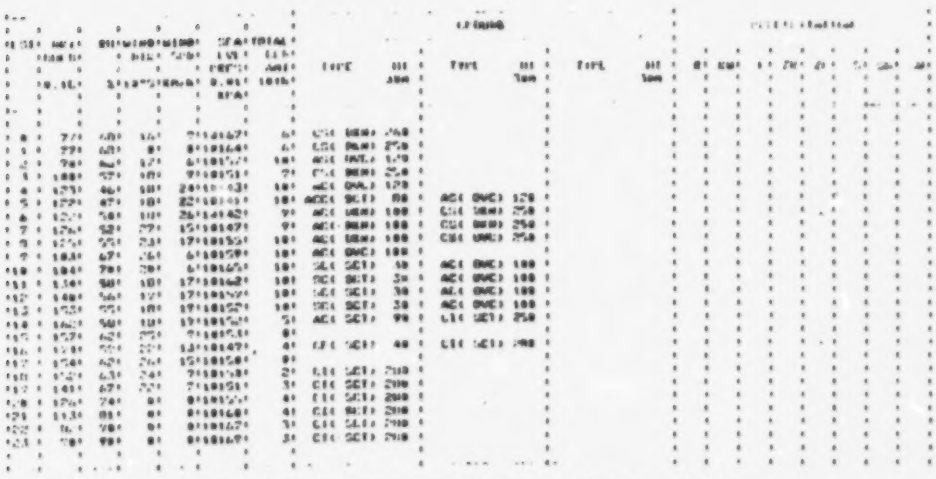


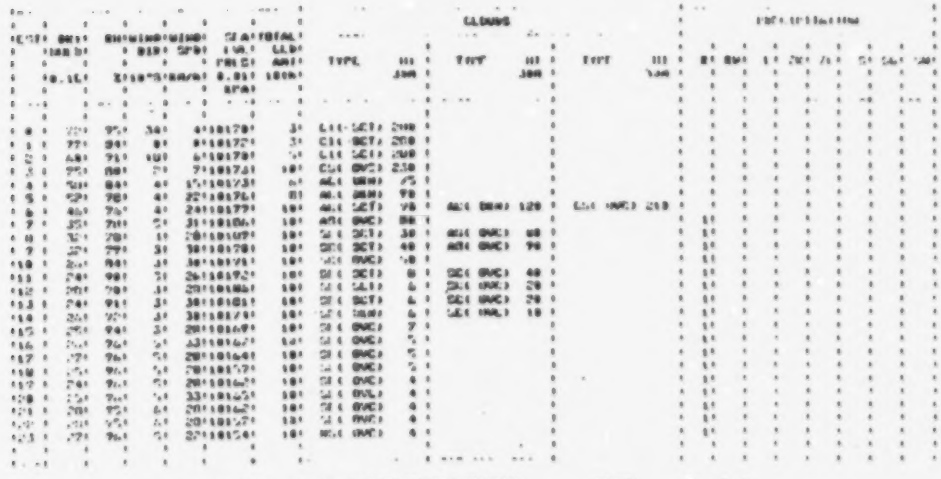


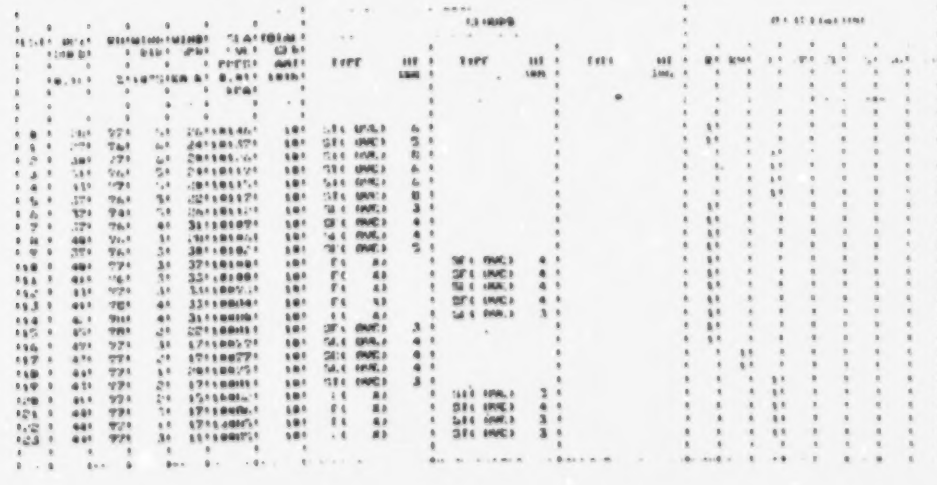






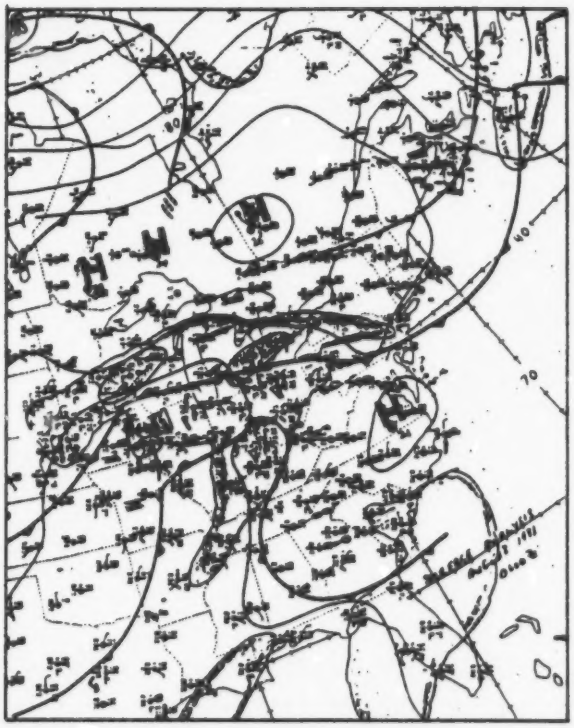


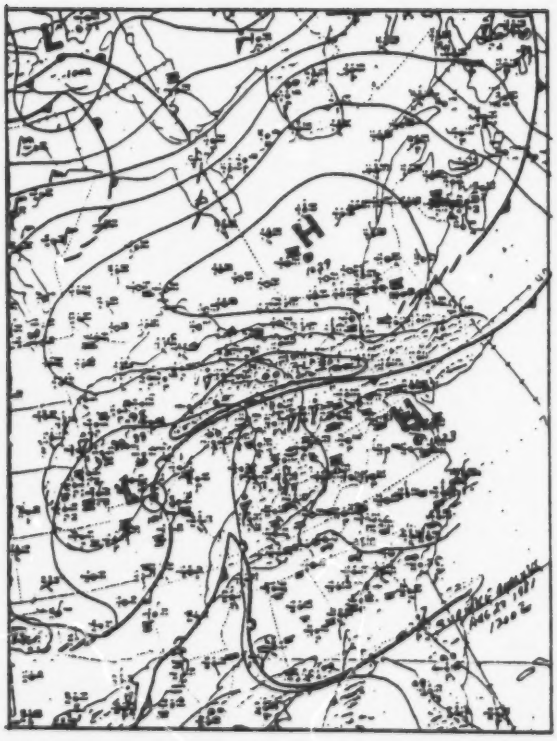


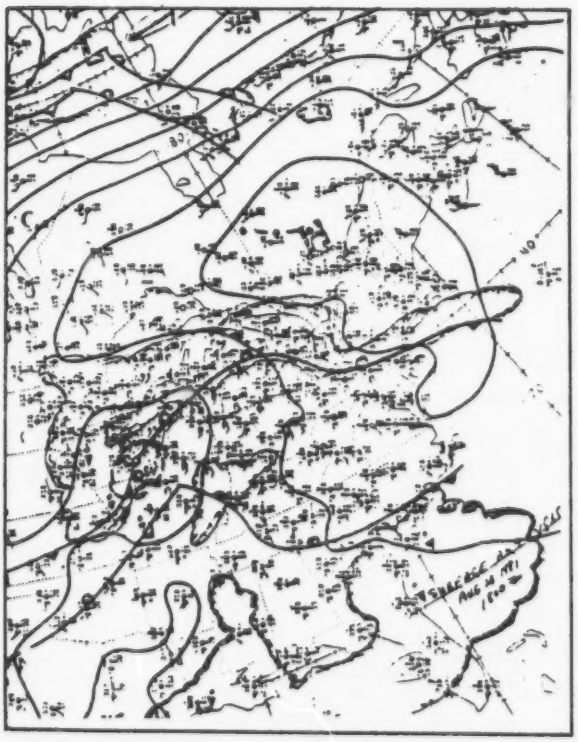


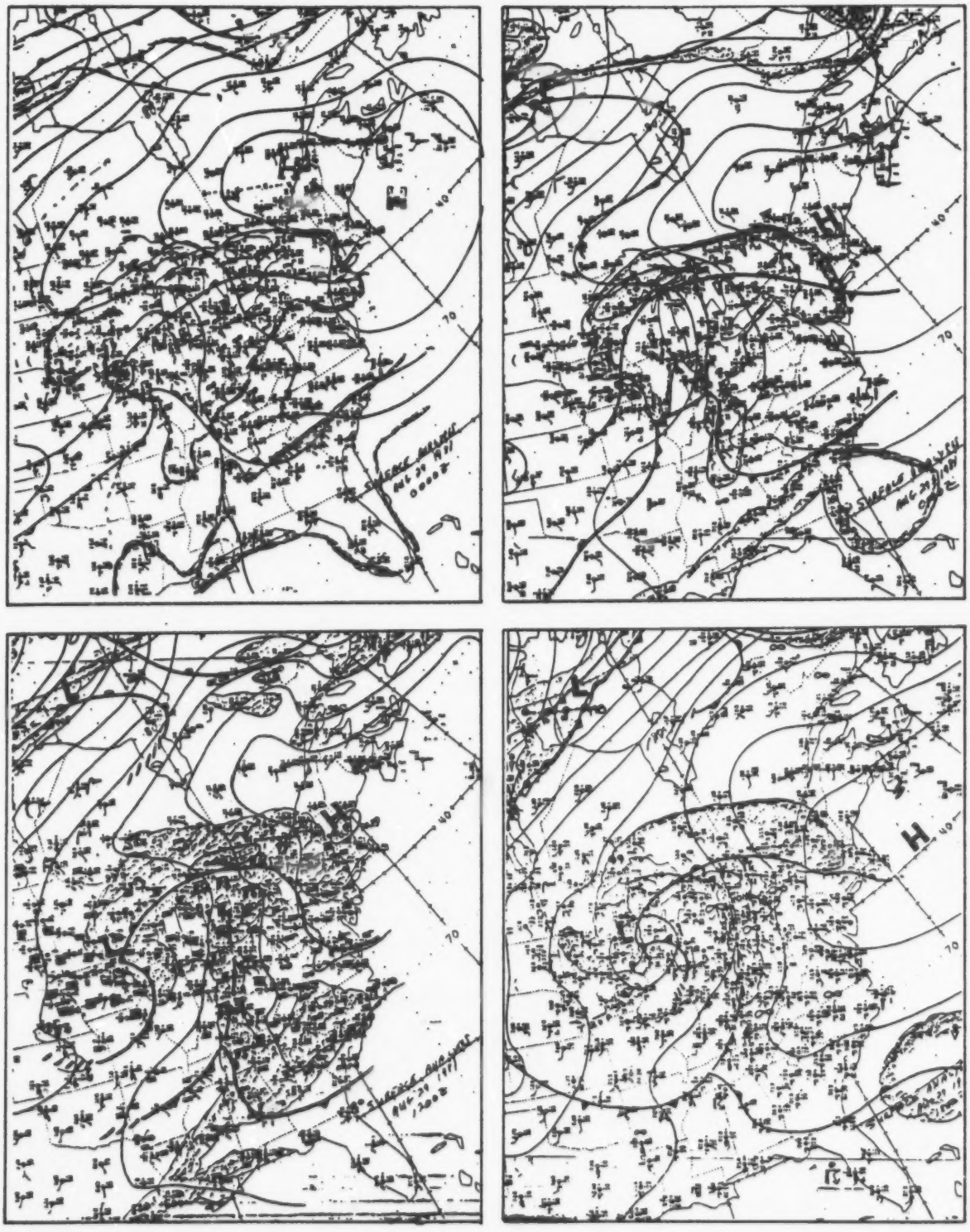
APPENDIX E

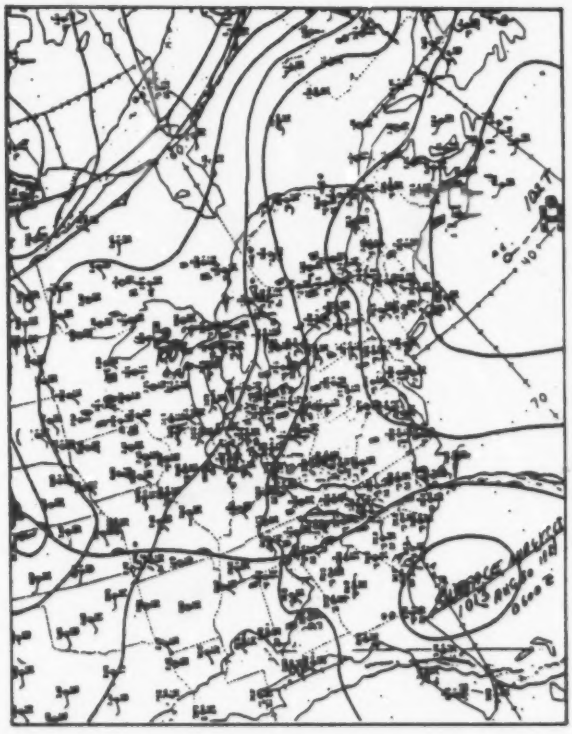
SURFACE SYNOPTIC WEATHER MAPS AND OBSERVATIONAL DATA FOR PRECIPITATION EPISODE 5: AUGUST 28 TO 31, 1981

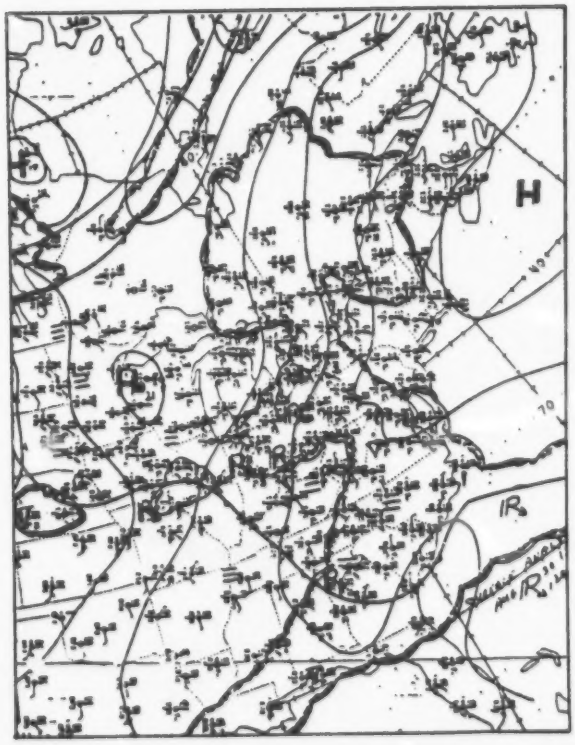


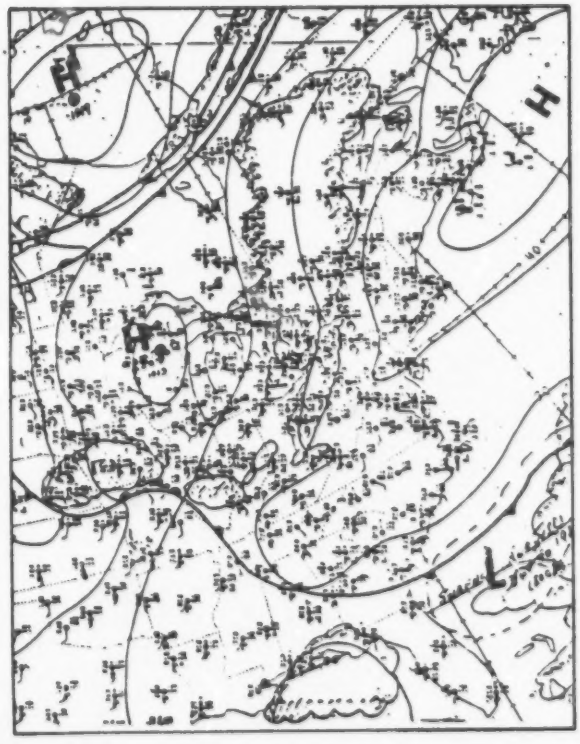


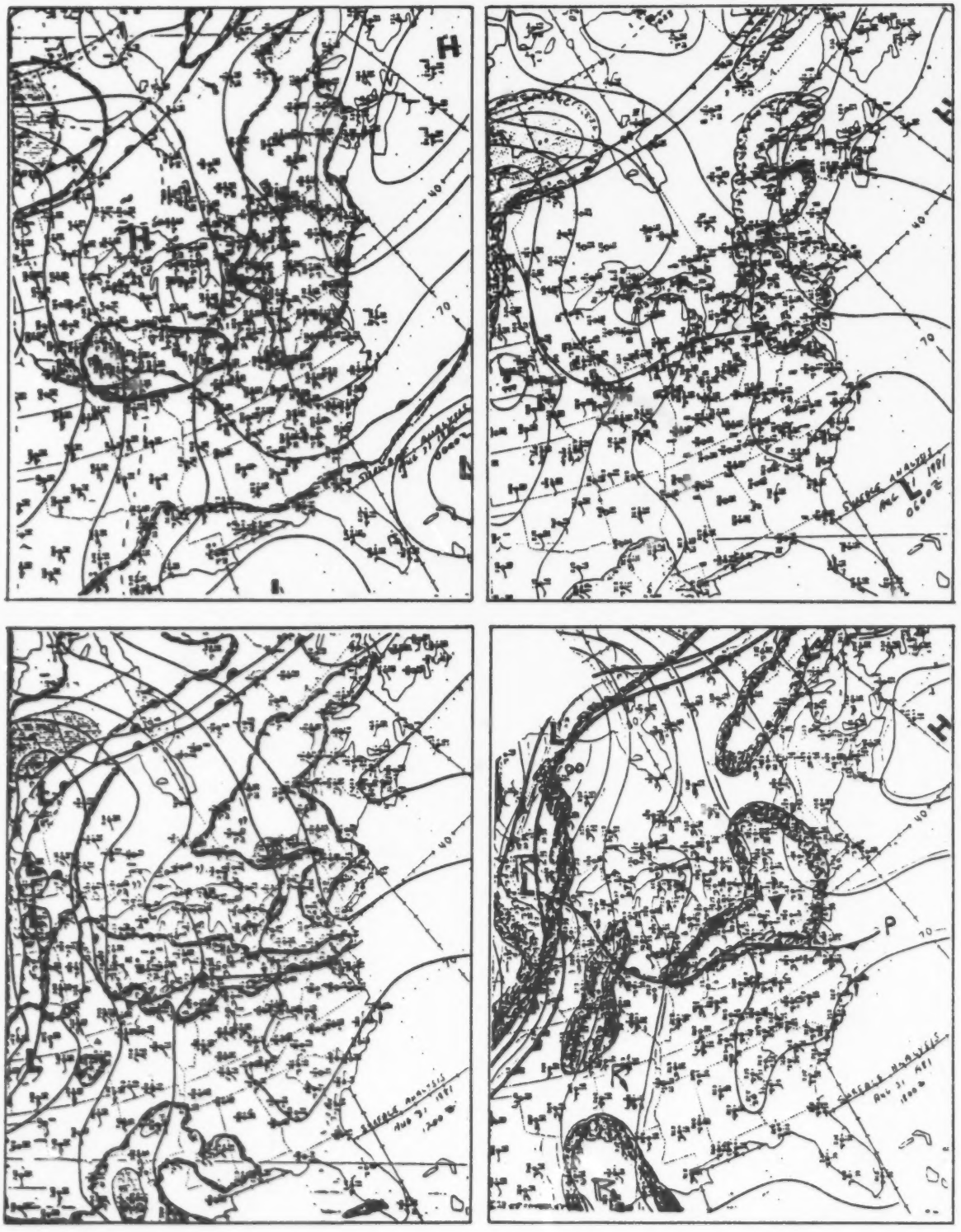


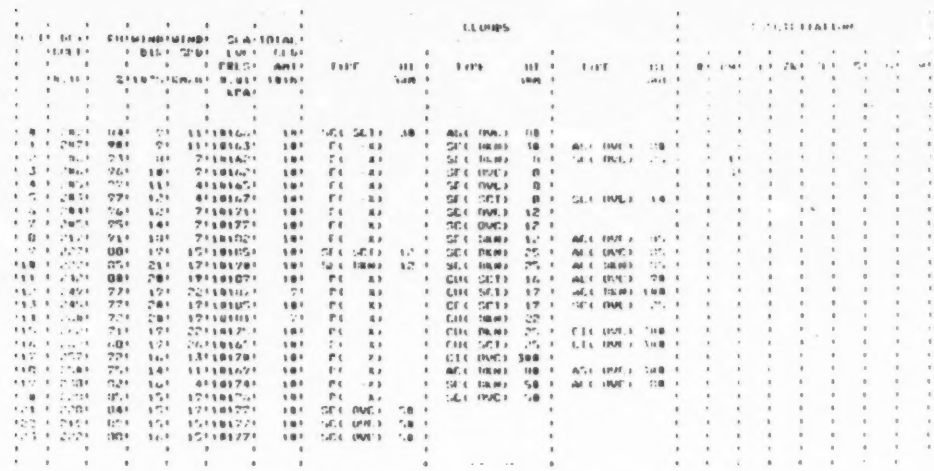


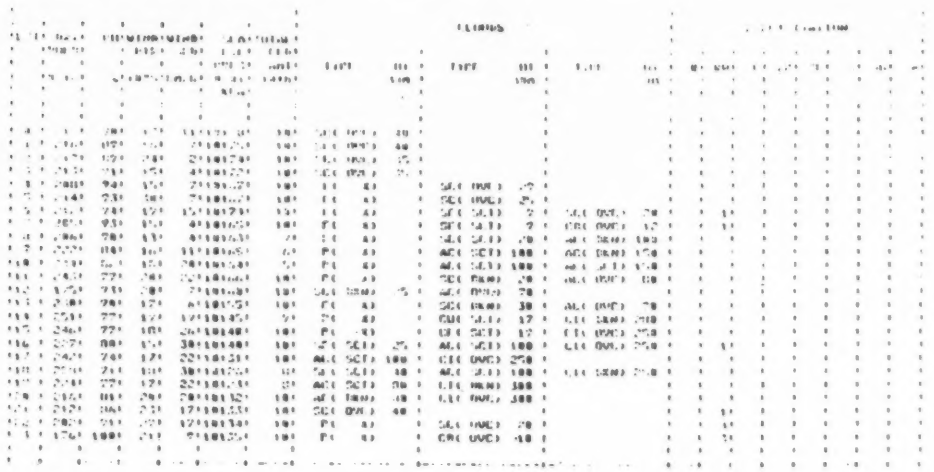


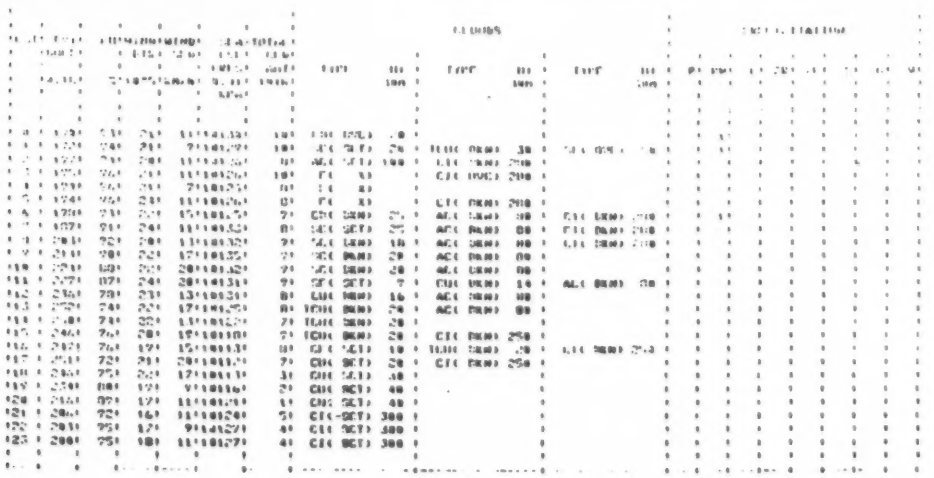

H

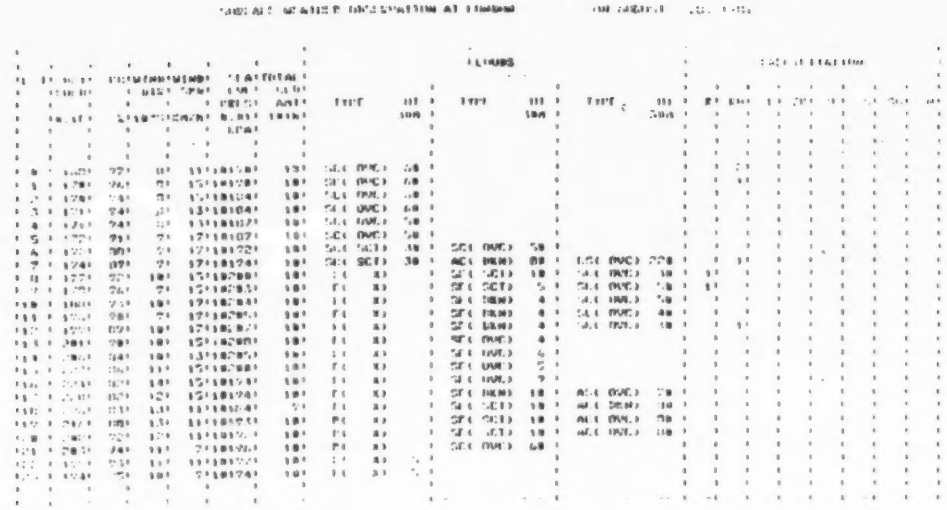

H
L

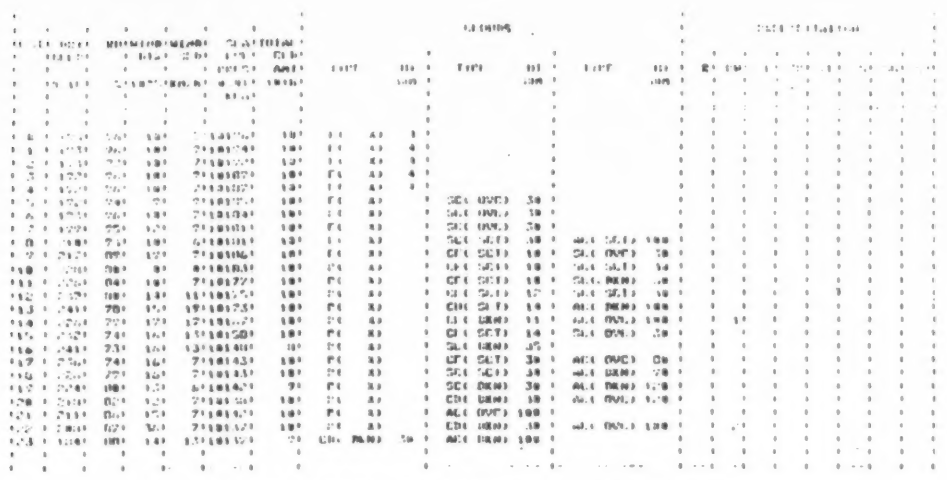


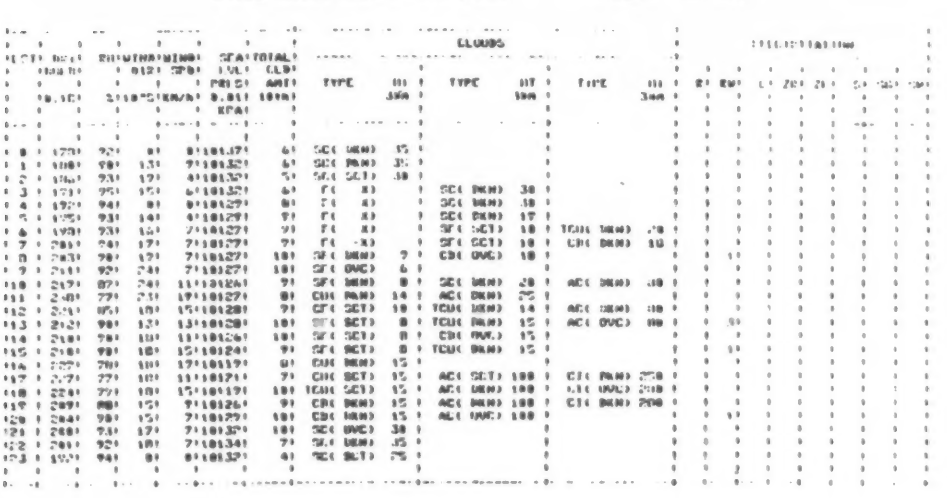


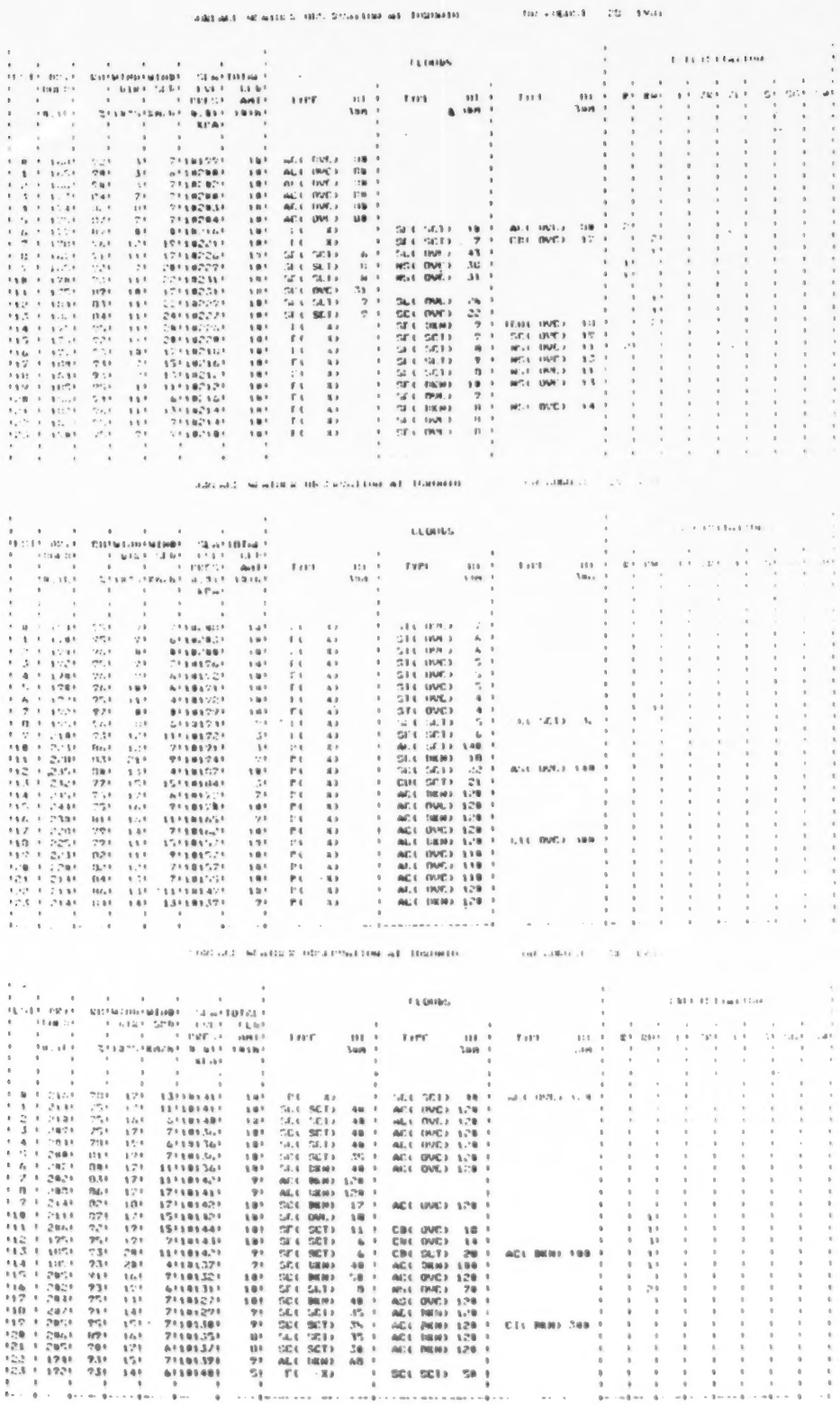


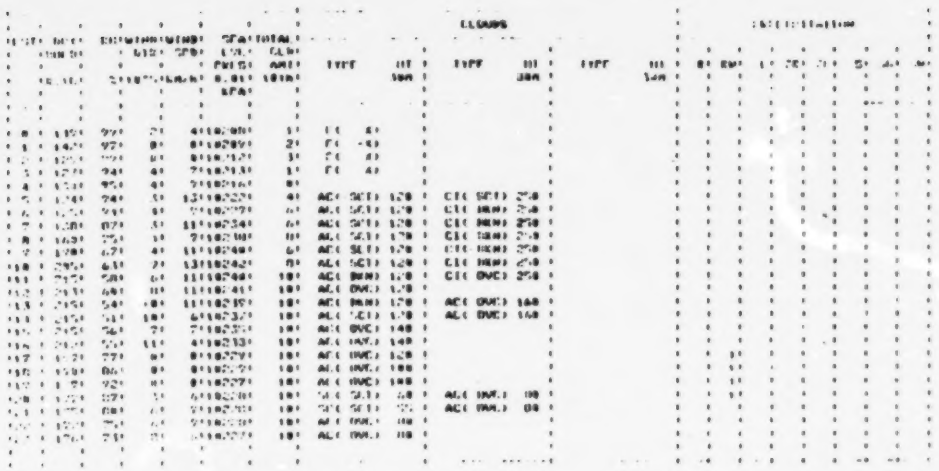


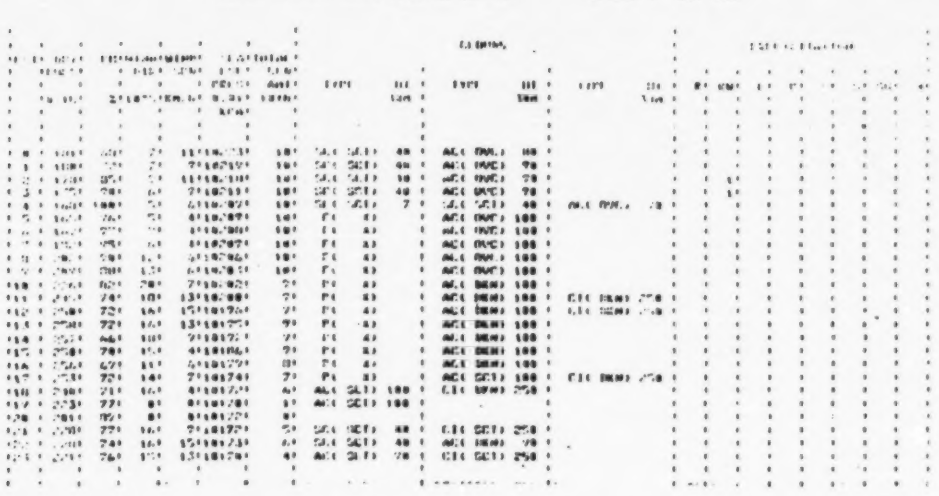


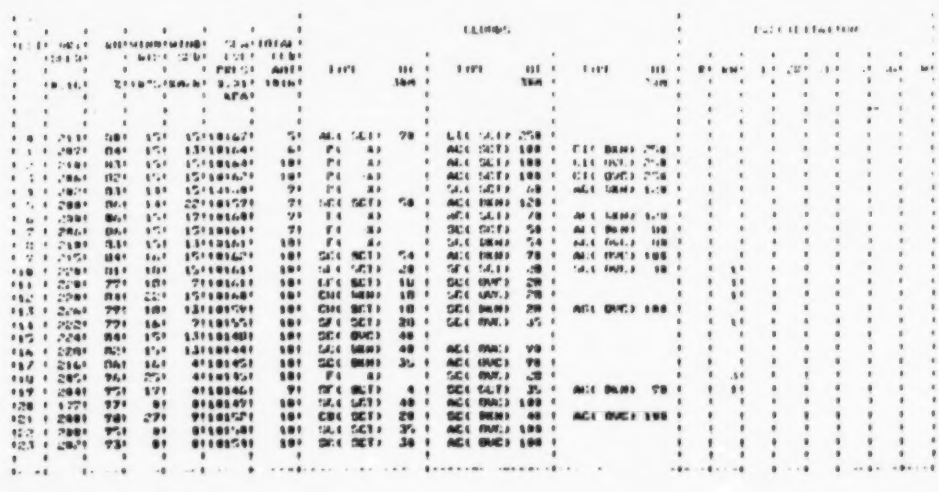


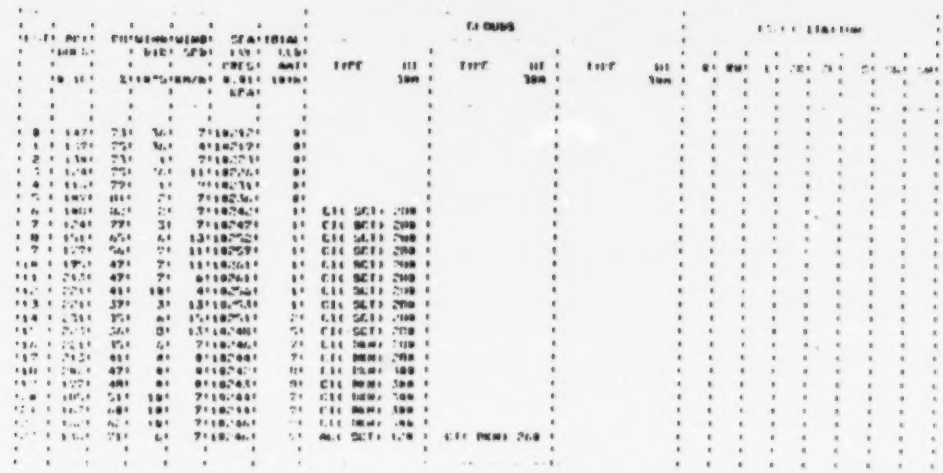


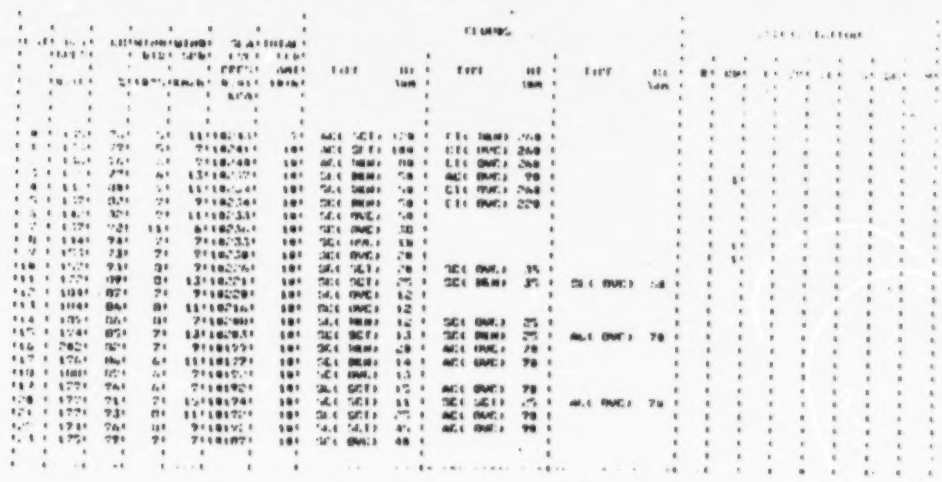


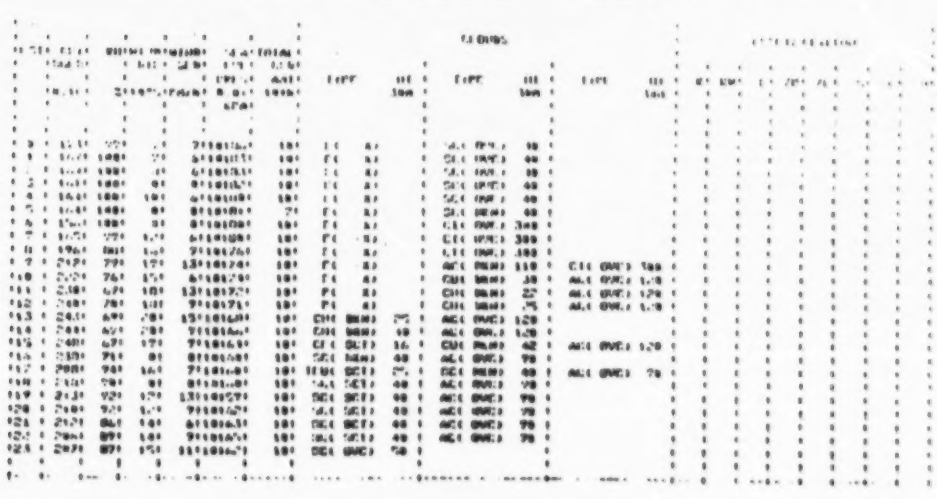


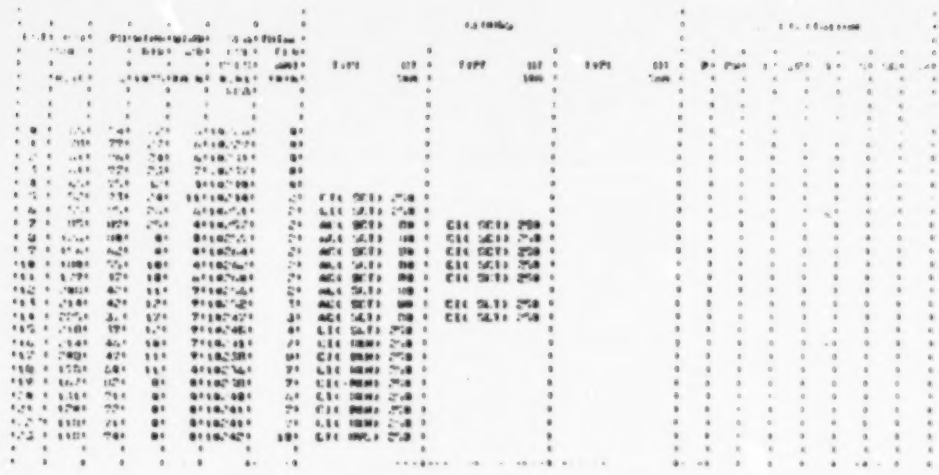


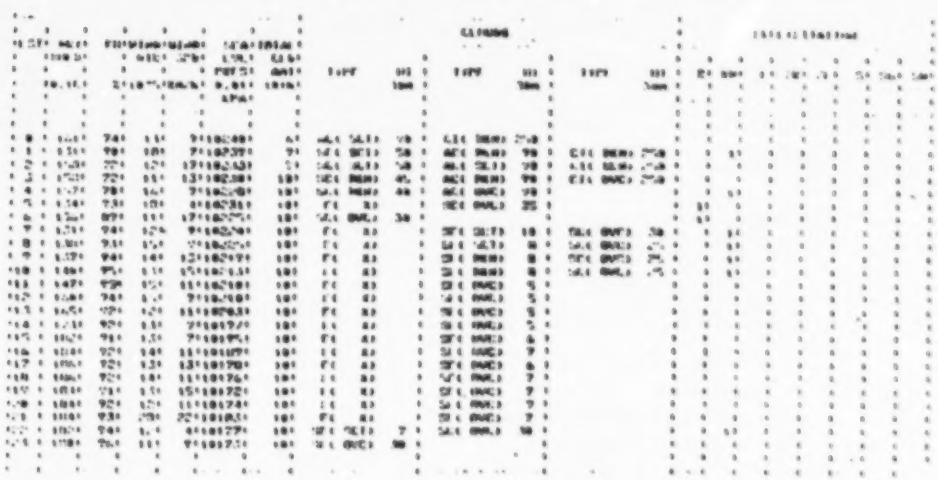


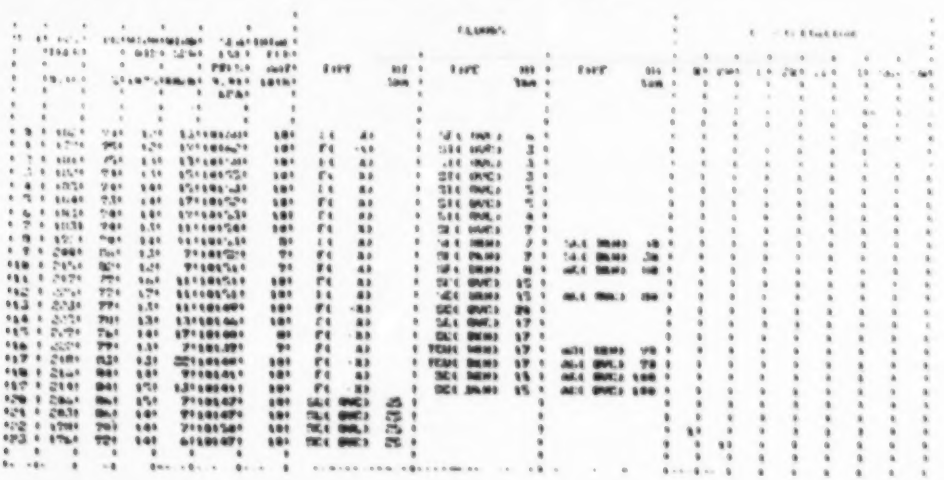


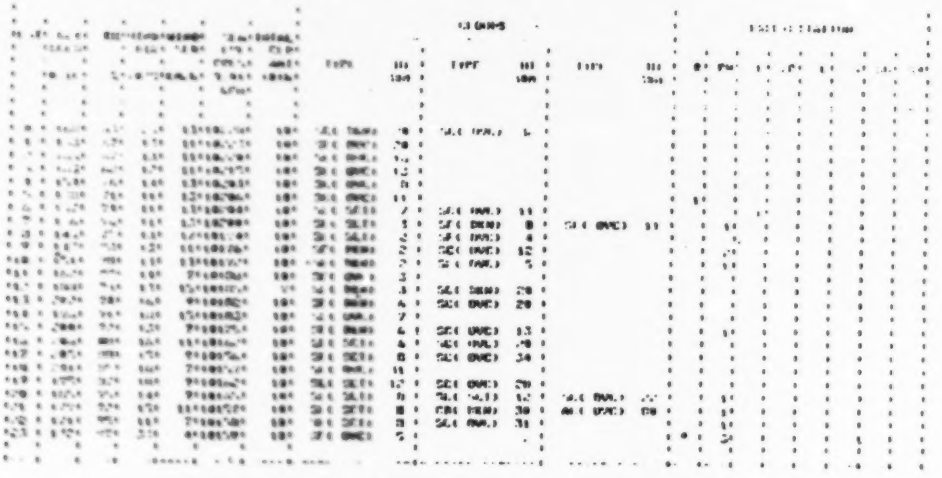


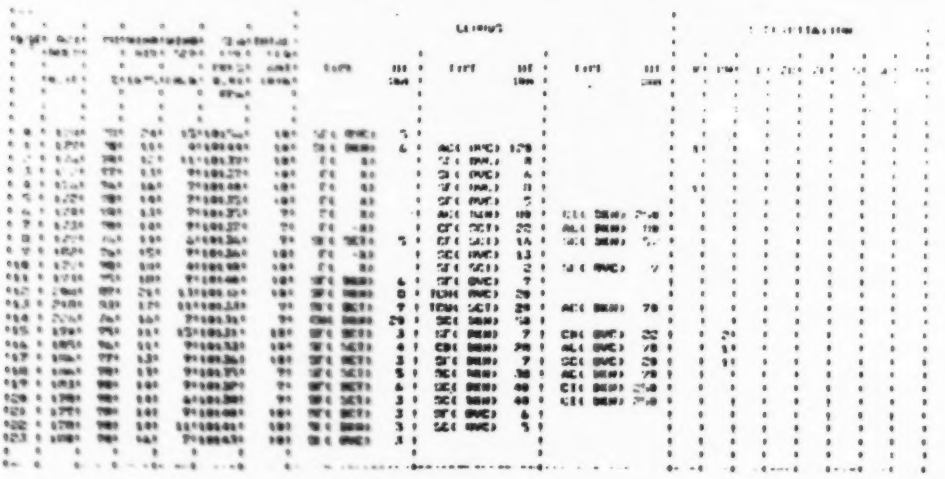


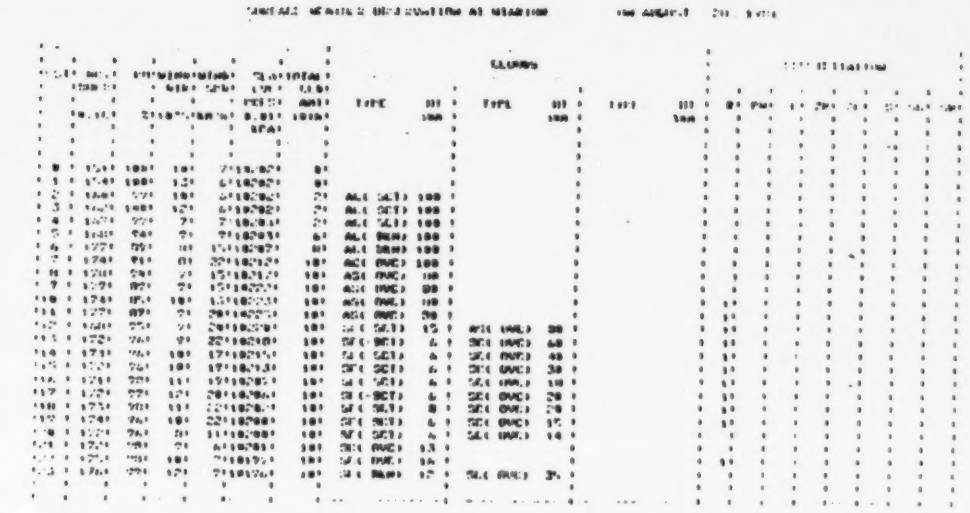


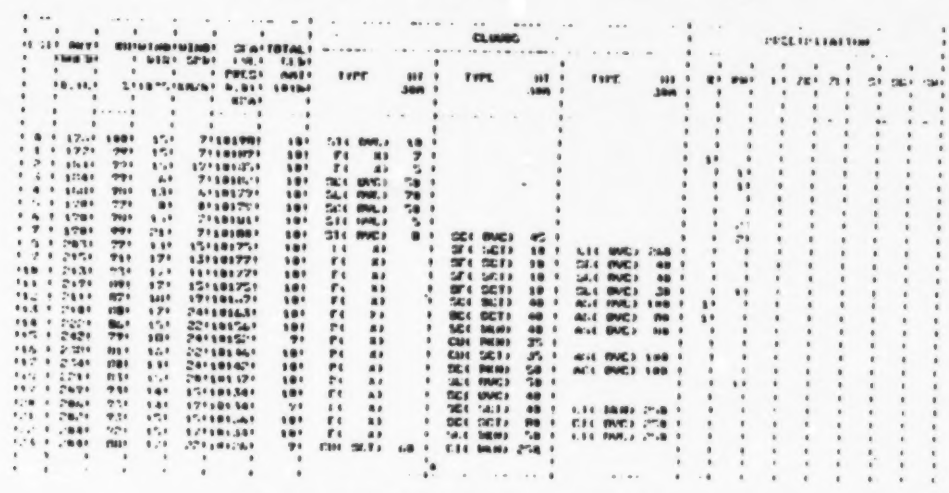


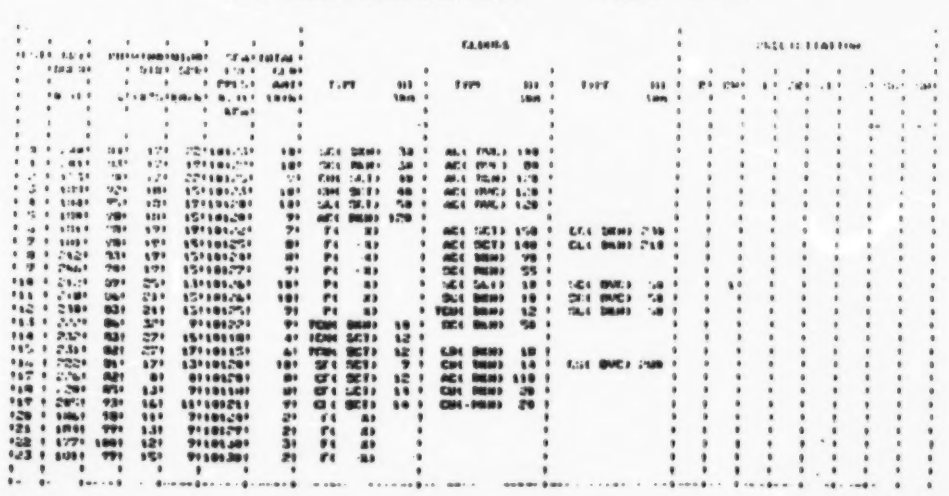


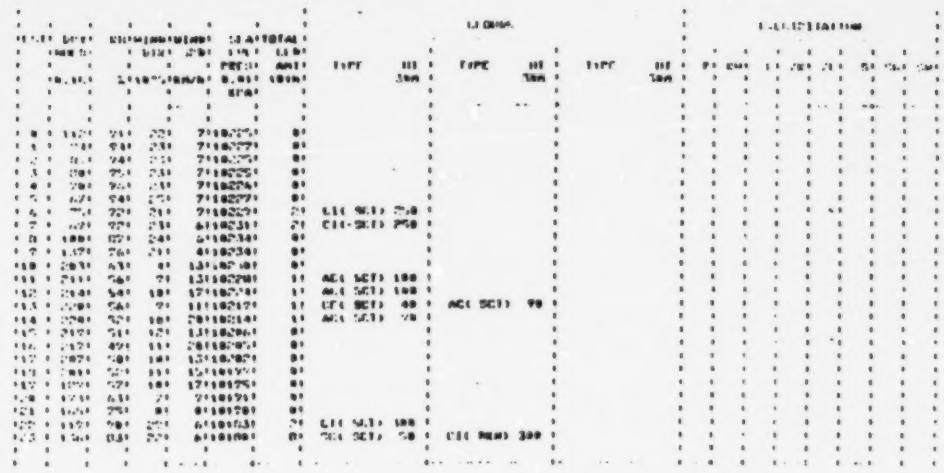


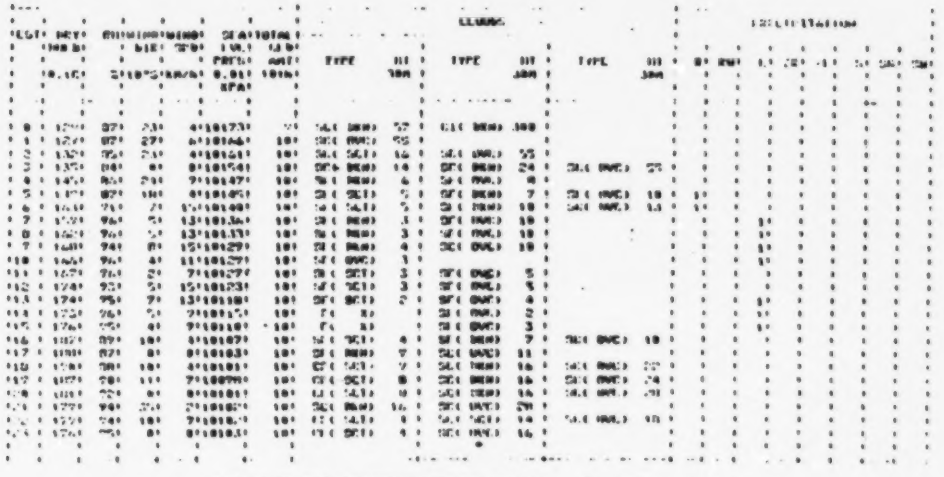


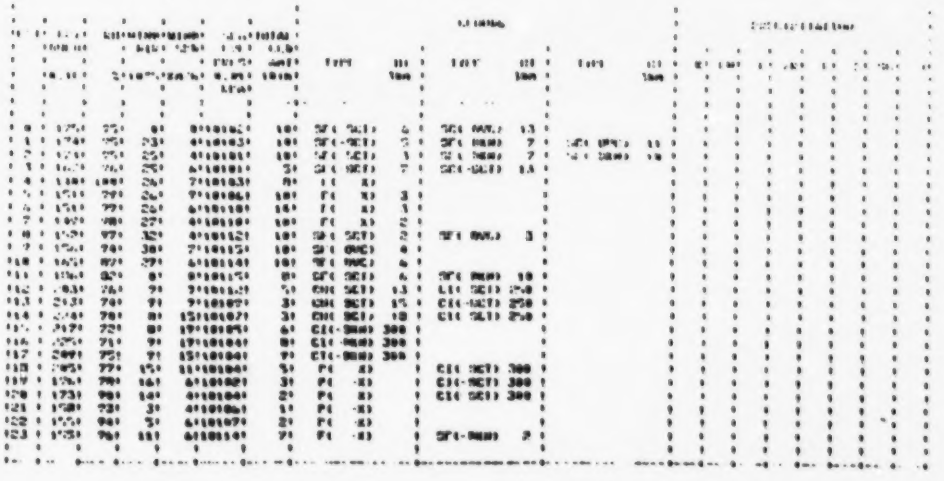












POOR
QUALITY
ORIGINAL